The Department of Defense

DoD Departments:

Department of the Navy

Department of the Air Force

Defense Advanced Research Projects Agency

Ballistic Missile Defense Organization

Defense Threat Reduction Agency

Special Operations Command

National Imagery and Mapping Agency

CBD

Chemical Biological Defense

Program Solicitation 02.1
Closing Date: 16 January 2002

FY 2002 SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM

PROGRAM SOLICITATION

Number 02.1

**Small Business
Innovation
Research Program**

IMPORTANT

The DoD updates its SBIR mailing list annually. To remain on the mailing list or to be added to the list, send in the Mailing List form (Reference H) found at the back of this solicitation or complete the electronic form at www.pbcinc.com/sbir/pdf/ref_h.pdf. Failure to send the form annually will result in removal of your name from the mailing list.

To stay in touch with the SBIR opportunities and to receive e-mail updates on the DoD SBIR and STTR programs you are invited to subscribe to the DoD ListServ by e-mailing LISTSERV@PEACH.EASE.LSOFT.COM. In the body of the message type SUB DODSBIRSTTR-L firstname lastname and send it. Or you may send a blank message to: DODSBIRSTTR-L-SUBSCRIBE REQUEST@PEACH.EASE.LSOFT.COM

If you have questions about the Defense Department's SBIR program, please call the SBIR/STTR Help Desk at (866) 216-4095, or see the DoD SBIR/STTR Web Site, at http://www.acq.osd.mil/sadbu/sbir.

U.S. Department of Defense
SBIR Program Office
Washington, DC 20301

DISTRIBUTION STATEMENT A
Approved for Public Release
Distribution Unlimited

October 1, 2001:	Solicitation issued for public release
December 3, 2001:	DoD begins accepting proposals
January 16, 2002:	Deadline for receipt of proposals at the DoD Components by 3:00 p.m. local time

OFFICE OF THE UNDER SECRETARY OF DEFENSE

3000 DEFENSE PENTAGON
WASHINGTON DC 20301-3000

ACQUISITION AND
TECHNOLOGY

IMPORTANT NEW INFORMATION ABOUT THE DOD SBIR PROGRAM

1. **The DoD SBIR/STTR Help Desk** can address your questions about this solicitation, proposal preparation, contract negotiations, getting paid, government accounting requirements, intellectual property protection, commercialization reporting, the Fast Track, and other program-related areas. You may contact the Help Desk by:
   Phone: 866-216-4095 (8AM to 6PM EST)*
   Fax: 866-888-1079
   Email: SBIRHELPDESK@pbcinc.com
   (*The Help Desk maintains extended hours 8 am – 8pm for the ten days previous to the close of the solicitation)

2. **The DoD SBIR/STTR Web Site (http://www.acq.osd.mil/sadbu/sbir)** offers electronic access to many important resources for SBIR participants, such as the initial public release of each SBIR solicitation, sample SBIR proposals, model SBIR contracts, links to the Component SBIR programs within DoD, answers to commonly-asked questions about SBIR contracting, descriptive data on the SBIR program, and the latest program updates.

3. **Your SBIR Proposal Cover Sheet (formerly, "Appendix A and B") and Company Commercialization Report must now be submitted electronically through www.dodsbir.net/submission**, as described in Sections 3.4b and n. If you submit a proposal, you must submit a company commercialization report whether or not you have previously received SBIR or STTR awards.

4. **DoD has adopted commercialization of SBIR technology (in military and/or private sector markets) as a critical measure of performance** for both the DoD SBIR program and the companies that participate in the program. This new policy is reflected in Sections 3.4h and 3.6 of this solicitation (Commercialization Strategy); Section 3.4n (Company Commercialization Report on Prior SBIR Awards); Section 4.4 (Assessing Commercial Potential of Proposals); and Section 5.4 (Commercialization Report Updates).

5. **Under DoD's "Fast Track" policy (Section 4.5), SBIR projects that attract some matching cash from an outside investor for the Phase II effort receive expedited processing and interim funding between Phases I and II.** See http://www.acq.osd.mil/sadbu/sbir/fsttrack.html#results.

6. **Fast Track application coversheets must be submitted electronically through www.dodsbir.net/submission.** Only the coversheets can be submitted electronically. The required letter from an outside investor and a concise statement of work for interim must still be submitted in hard copy with the signed, printed Fast Track coversheet.

7. **Each DoD Component (Army, Navy, Air Force, etc.) has developed its own Phase II Enhancement policy.** Under this policy, the Component will provide a Phase II company with additional Phase II SBIR funding if the company can match the additional SBIR funds with non-SBIR funds from DoD acquisition programs or the private sector. See each Component's section of the solicitation for details.

8. **You may contact the DoD authors of solicitation topics to ask questions about the topics** before you submit a proposal. Procedures for doing so are discussed in Section 1.5c of this solicitation. Please note that you may talk by telephone with a topic author to ask such questions only between May 1, when this solicitation was publicly released, and July 2, when DoD begins accepting proposals. At other times, you may submit written questions as described in Section 1.5c.

9. **A number of the Navy and Air Force topics are supported by a DoD acquisition program (e.g. New Attack Submarine)**, as noted in the text of the topic. These acquisition programs are potentially important end customers for innovative new products resulting from SBIR projects. Information on how to contact these programs is posted on the DoD SBIR/STTR Web Site, at http://www.acq.osd.mil/sadbu/sbir/acqprog/liaisons.htm

10. **Beginning October 2002, all DoD SBIR and STTR solicitations will be available in electronic format only from the DoD SBIR/STTR web site**, in accordance with the Government Paperwork Elimination Act (GPEA).

11. **The DoD will maintain the ListServ e-mail broadcast service. To stay in touch with SBIR opportunites, subscribe to the DoD ListServ by e-mailing LISTSERV@PEACH.EASE.LSOFT.COM**. In the body of the message, type SUB DODSBIRSTTR-L firstname lastname and send. Or you may send a blank message to: DODSBIRSTTR-L-SUBSCRIBE REQUEST@PEACH .EASE.LSOFT.COM. As always, you are encouraged to visit the DoD SBIR website periodically for changes to the SBIR and STTR programs. Additional questions about this policy can be directed to the DoD SBIR Help Desk at 1-866-216-4095 or via e-mail at sbirhelpdesk@pbcinc.com, Additional information about this policy directive can be found at www.acq.osd.mil/sadbu/sbir.

12. **PL106-554, which reauthorized the SBIR program through 2008, establishes the collection of "output and outcomes data"**. The DoD has been collecting much of this data through the Submission site; however, a few new data collection fields have been added. Carefully review your firm and Phase II commercialization information on www.dodsbir.net/submission and enter the necessary updates and entries.

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DoD PROGRAM SOLICITATION FOR SMALL BUSINESS INNOVATION RESEARCH

1.0 PROGRAM DESCRIPTION

1.1 Introduction

The Navy, Air Force, Defense Advanced Research Projects Agency (DARPA), Ballistic Missile Defense Organization (BMDO) Defense Threat Reduction Agency (DTRA), U.S. Special Operations Command (SOCOM), National Imagery and Mapping Agency (NIMA), and Chemical and Biological Defense (CBD) hereafter referred to as DoD Components, invite small business firms to submit proposals under this solicitation for the Small Business Innovation Research (SBIR) program. Firms with the capability to conduct research and development (R&D) in any of the defense-related topic areas described in Section 8.0, and to commercialize the results of that R&D, are encouraged to participate.

Objectives of the DoD SBIR Program include stimulating technological innovation, strengthening the role of small business in meeting DoD research and development needs, fostering and encouraging participation by minority and disadvantaged persons in technological innovation, and increasing the commercial application of DoD-supported research or research and development results.

The Federal SBIR Program is mandated by Public Laws PL 97-219, PL 99-443, PL 102-564 and PL 106-554. The basic design of the DoD SBIR Program is in accordance with the Small Business Administration (SBA) SBIR Policy Directive, January 1993. The DoD Program presented in this solicitation strives to encourage scientific and technical innovation in areas specifically identified by DoD Components. The guidelines presented in this solicitation incorporate and exploit the flexibility of the SBA Policy Directive to encourage proposals based on scientific and technical approaches most likely to yield results important to the DoD and the private sector.

1.2 Three Phase Program

This program solicitation is issued pursuant to the Small Business Innovation Development Act of 1982, PL 97-219, PL 99-443, PL 102-564 and PL 106-554. Phase I is to determine, insofar as possible, the scientific, technical, and commercial merit and feasibility of ideas submitted under the SBIR Program. Phase I awards are typically \$60,000 to \$100,000 in size over a period not to exceed six months (nine months for the Air Force). Proposals should concentrate on that research or research and development which will significantly contribute to proving the scientific, technical, and commercial feasibility of the proposed effort, the successful completion of which is a prerequisite for further DoD support in Phase II. The measure of Phase I success includes evaluations of the extent to which Phase II results would have the potential to yield a product or process of continuing importance to DoD and the private sector. Proposers are encouraged to consider whether the research or research and development they are proposing to DoD Components also has private sector potential, either for the proposed application or as a base for other applications.

Subsequent Phase II awards will be made to firms on the basis of results of their Phase I effort and the scientific, technical, and commercial merit of the Phase II proposal. Phase II awards are typically \$500,000 to \$750,000 in size over a period generally not to exceed 24 months (subject to negotiation). Phase II is the principal research or research and development effort and is expected to produce a well-defined deliverable prototype. A more comprehensive proposal will be required for Phase II.

Under Phase III, the small business is expected to obtain funding from the private sector and/or non-SBIR Government sources to develop the prototype into a viable product or non-R&D service for sale in military and/or private sector markets.

Under a policy approved by the Under Secretary of Defense for Acquisition and Technology in October 1998, DoD now tracks the extent to which technologies developed under Phase II are successfully commercialized in Phase III (in military and/or private sector markets), as discussed in Section 5.4 of this solicitation. Furthermore, DoD has adopted such commercialization success as a critical measure of performance for both the DoD SBIR program and the firms that participate in the program.

This solicitation is for Phase I proposals only. Only proposals submitted in response to this solicitation will be considered for Phase I award. Only proposals submitted in response to topics contained in this solicitation will be accepted. Proposers who were not awarded a contract in response to a prior SBIR solicitation are free to update or modify and re-submit the same or modified proposal if it is responsive to any of the topics listed in Section 8.

For Phase II, no separate solicitation will be issued and no unsolicited proposals will be accepted. Only those firms that were awarded Phase I contracts will be considered (Section 4.3 and 5.2).

DoD is not obligated to make any awards under either Phase I, II, or III, and all awards are subject to the availability of funds. DoD is not responsible for any monies expended by the proposer before award of any contract.

1.3 Proposer Eligibility and Limitations

Each proposer must qualify as a small business for research or research and development purposes as defined in Section 2.0 and certify to this on the Cover Sheet of the proposal. In addition, a minimum of <u>two-thirds</u> of the research and/or analytical work in Phase I must be carried out by the proposing firm. For Phase II, a minimum of <u>one-half</u> of the research and/or analytical work must be performed by the proposing firm. The percent of work is

usually measured by both direct and indirect costs, although proposers planning to subcontract a significant fraction of their work should verify how it will be measured with their DoD contracting officer during contract negotiations. For both Phase I and II, the primary employment of the principal investigator must be with the small business firm at the time of the award and during the conduct of the proposed effort. Primary employment means that more than one-half of the principal investigator's time is spent with the small business. Primary employment with a small business concern precludes full-time employment at another organization. Deviations from the requirements in this paragraph must be approved in writing by the contracting officer (during contract negotiations).

For both Phase I and Phase II, all research or research and development work must be performed by the small business concern in the United States. "United States" means the fifty states, the Territories and possessions of the United States, the Commonwealth of Puerto Rico, the Commonwealth of the Northern Mariana Islands, the Trust Territory of the Pacific Islands, and the District of Columbia.

Joint ventures and limited partnerships are permitted, provided that the entity created qualifies as a small business in accordance with the Small Business Act, 15 USC 631, and the definition included in Section 2.2.

1.4 Conflicts of Interest

Awards made to firms owned by or employing current or previous Federal Government employees could create conflicts of interest for those employees in violation of federal law. Such proposers should contact the cognizant Ethics Counselor from the employees' Government agency for further guidance.

1.5 Questions about SBIR and Solicitation Topics

a. General Questions/Information. The DoD SBIR/STTR Help Desk is prepared to address general questions about this solicitation, the proposal preparation process, contract negotiation, payment vouchers, Government accounting requirements, intellectual property protection, the Fast Track, financing strategies, and other program-related areas. The Help Desk may be contacted by:

Phone: 866-216-4095 (8AM to 6PM EST)
Fax: 866-888-1079
Email: SBIRHELPDESK@pbcinc.com

The DoD SBIR/STTR Web Site offers electronic access to SBIR solicitations, answers to commonly asked questions, sample SBIR proposals, model SBIR contracts, abstracts of ongoing SBIR projects, the latest updates on the SBIR program, hyperlinks to sources of business assistance and financing, and other useful information.

b. General Questions about a DoD Component. General questions pertaining to a particular DoD Component (Army, Navy, Air Force, etc) should be submitted in accordance with the instructions given at the beginning of that Component's topics, in Section 8.0 of this solicitation.

c. Technical Questions about Solicitation Topics. On October 1, 2001, this solicitation was issued for public release on the DoD SBIR/STTR Web Site (**http://www.acq.osd.mil/sadbu/sbir**), along with the names of the topic authors and their phone numbers. The names of topic authors and their phone numbers will remain posted on the Web Site until December 3, 2001, giving proposers an opportunity to ask technical questions about specific solicitation topics by telephone.

Once DoD begins accepting proposals on December 3, 2001, telephone questions will no longer be accepted, but proposers may submit written questions through the SBIR Interactive Topic Information System (SITIS), in which the questioner and respondent remain anonymous and all questions and answers are posted electronically for general viewing. Proposers may submit written questions to SITIS via the Internet (see "Solicitations" on the DoD SBIR/STTR Web Site), e-mail, fax, mail, or telephone as follows:

Defense Technical Information Center
MATRIS Office, DTIC-AM
ATTN: SITIS Coordinator
NAS North Island, Box 357011
San Diego, CA 92135-7011
Phone: (619) 545-7529
Fax: (619) 545-0019
E-mail: sbir@dticam.dtic.mil
www: http://dticam.dtic.mil/sbir/

The SITIS service for this solicitation opens on or around October 17, 2001 and closes to new questions on December 28, 2001. SITIS will post all questions and answers on the Internet (see Solicitations on the DoD SBIR/STTR Web Site) from October 17,2001 through January 16, 2002. (Answers will also be emailed or faxed directly to the inquirer if the inquirer provides an e-mail address or fax number.) Answers are generally posted within seven working days of question submission.

All proposers are advised to monitor SITIS during the solicitation period for questions and answers, and other information, relevant to the topic under which they are proposing.

1.6 Requests for Copies of DoD SBIR Solicitations

To remain on the DoD Mailing list for the SBIR and STTR solicitations, send in the Mailing List form (Reference H). You may also order additional copies of this solicitation from:

DoD SBIR Support Services
7000 North Broadway
Building 1, Suite #108
Denver, CO 80221
(866) 216-4095

The DoD SBIR and STTR solicitations can also be accessed via internet through the DoD SBIR/STTR Web Site at **http://www.acq.osd.mil/sadbu/sbir** or **www.dodsbir.net**.

DOD SBIR/STTR WEB SITE:
http://www.acq.osd.mil/sadbu/sbir

1.7 SBIR Conferences and Outreach

The DoD co-sponsors two National SBIR Conferences a year and participates in many state-organized conferences for small business. For information on these events, see "Conferences" on our Web Site (**http://www.acq.osd.mil/sadbu/sbir**). We have a special outreach effort to socially and economically disadvantaged firms.

2.0 DEFINITIONS

The following definitions apply for the purposes of this solicitation:

2.1 Research or Research and Development

Basic Research - Scientific study and experimentation to provide fundamental knowledge required for the solution of problems.

Exploratory Development - A study, investigation or minor development effort directed toward specific problem areas with a view toward developing and evaluating the feasibility and practicability of proposed solutions.

Advanced Development - Proof of design efforts directed toward projects that have moved into the development of hardware for test.

Engineering Development - Full-scale engineering development projects for DoD use but which have not yet received approval for production.

2.2 Small Business

A small business concern is one that, at the time of award of a Phase I or Phase II contract:

a. Is independently owned and operated and organized for profit, is not dominant in the field of operation in which it is proposing, and has its principal place of business located in the United States;

b. Is at least 51% owned, or in the case of a publicly owned business, at least 51% of its voting stock is owned by United States citizens or lawfully admitted permanent resident aliens;

c. Has, including its affiliates, a number of employees not exceeding 500, and meets the other regulatory requirements found in 13 CFR Part 121. Business concerns, other than investment companies licensed, or state development companies qualifying under the Small Business Investment Act of 1958, 15 USC 661, et seq., are affiliates of one another when either directly or indirectly (1) one concern controls or has the power to control the other; or (2) a third party or parties controls or has the power to control both. Control can be exercised through common ownership, common management, and contractual relationships. The term "affiliates" is defined in greater detail in 13 CFR Sec. 121.103. The term "number of employees" is defined in 13 CFR Sec. 121.106. Business concerns include, but are not limited to, any individual, partnership, corporation, joint venture, association or cooperative.

2.3 Socially and Economically Disadvantaged Small Business

A small business that is at the time of award of a Phase I or Phase II contract:

a. At least 51% owned by an Indian tribe or a native Hawaiian organization, or one or more socially and economically disadvantaged individuals, and

b. Whose management and daily business operations are controlled by one or more socially and economically disadvantaged individuals.

A socially and economically disadvantaged individual is defined as a member of any of the following groups: Black Americans, Hispanic Americans, Native Americans, Asian-Pacific Americans, Subcontinent-Asian Americans, or other groups designated by SBA to be socially and economically disadvantaged.

2.4 Women-Owned Small Business

A women-owned small business is one that is at least 51% owned by a woman or women who also control and operate it. "Control" in this context means exercising the power to make policy decisions. "Operate" in this context means being actively involved in the day-to-day management of the business.

2.5 Funding Agreement

Any contract, grant, or cooperative agreement entered into between any Federal Agency and any small business concern for the performance of experimental, developmental, or research work funded in whole or in part by the federal Government. *Only the contract method will be used by DoD components for all SBIR awards.*

2.6 Subcontract

A subcontract is any agreement, other than one involving an employer-employee relationship, entered into by a Federal Government contract awardee calling for supplies or services required solely for the performance of the original contract. This includes consultants.

2.7 Commercialization

The process of developing a product or non-R&D service for sale (whether by the originating party or by others), in Government and/or private sector markets.

3.0 PROPOSAL PREPARATION INSTRUCTIONS AND REQUIREMENTS

3.1 Proposal Requirements

A proposal to any DoD Component under the SBIR Program is to provide sufficient information to persuade the DoD Component that the proposed work represents an innovative approach to the investigation of an important scientific or engineering problem and is worthy of support under the stated criteria.

The quality of the scientific or technical content of the proposal will be the principal basis upon which proposals will be evaluated. The proposed research or research and development must be responsive to the chosen topic, although need not use the exact approach specified in the topic (see Section 4.1). Any small business contemplating a bid for work on any specific topic should determine that (a) the technical approach has a reasonable chance of meeting the topic objective, (b) this approach is innovative, not routine, and (c) the firm has the capability to implement the technical approach, i.e. has or can obtain people and equipment suitable to the task.

Those responding to this solicitation should note the proposal preparation tips listed below:

1) Read and follow all instructions contained in this solicitation, including the instructions in Section 8.0 of the DoD component to which you are applying.
2) Use the free technical information services from DTIC and other information assistance organizations (Section 7.1 - 7.4).
3) Mark proprietary information as instructed in Sec. 5.6.
4) Limit your proposal to 25 pages (excluding Company Commercialization Report).
5) Use a type size no smaller than a 10-point font.
6) Register your firm on the DoD Electronic Submission Web Site (http://www.dodsbir.net/submission) and, as instructed on the Web Site, prepare a Proposal Cover Sheet and Company Commercialization Report to be included in your proposal.
7) Public access to the internet is available at most public libraries, local schools or a Small Business Development Center (SBDC) in your area. If you have any questions, please contact the DoD Help Desk (866-216-4095). <u>The Help Desk **cannot** perform electronic proposal submission on behalf of any firm.</u>

3.2 Proprietary Information

If information is provided which constitutes a trade secret, proprietary commercial or financial information, confidential personal information, or data affecting the national security, it will be treated in confidence to the extent permitted by law, provided it is clearly marked in accordance with Section 5.6. <u>The cost proposal information, will be treated as proprietary whether or not it is indicated.</u>

3.3 Limitations on Length of Proposal

This solicitation is designed to reduce the investment of time and cost to small firms in preparing a formal proposal. Those who wish to respond must submit a direct, concise, and informative research or research and development proposal of no more than 25 pages, excluding Company Commercialization Report, (no type smaller than 10-point on standard 8 ½ " X 11" paper with one (1) inch margins, and a maximum of 6 lines per inch), *including Proposal Cover Sheet, Cost Proposal, and any enclosures or attachments.* Promotional and non-project related discussion is discouraged. <u>Cover all items listed below in Section 3.4 in the order given.</u> The space allocated to each will depend on the problem chosen and the principal investigator's approach. In the interest of equity, proposals in excess of the 25-page limitation (including attachments, appendices, or references, but excluding Company Commercialization Report <u>will not</u> be considered for review or award.

3.4 Phase I Proposal Format

a. Page Numbering. Number all pages of your proposal consecutively.

b. Proposal Cover Sheet. Register your firm on the password-protected DoD Electronic Submission Web Site (http://www.dodsbir.net/submission). As instructed on the Web Site, prepare a Proposal Cover Sheet, including a brief technical abstract of the proposed R&D project and a discussion of anticipated benefits and potential commercial applications. If your proposal is selected for award, the technical abstract and discussion of anticipated benefits will be publicly released on the Internet; therefore, do not include proprietary or classified information in these

sections. Print out a hard copy of the Proposal Cover Sheet from the Web Site and include it, with the appropriate signatures, as the first two pages of your proposal. Also include a photocopy of the signed Proposal Cover Sheet in the additional copies of the proposal that you submit per Section 6.0 of this solicitation

c. Identification and Significance of the Problem or Opportunity. Define the specific technical problem or opportunity addressed and its importance. (Begin on Page 3 of your proposal.)

d. Phase I Technical Objectives. Enumerate the specific objectives of the Phase I work, including the questions it will try to answer to determine the feasibility of the proposed approach.

e. Phase I Work Plan. Provide an explicit, detailed description of the Phase I approach. The plan should indicate what is planned, how and where the work will be carried out, a schedule of major events, and the final product to be delivered. The Phase I effort should attempt to determine the technical feasibility of the proposed concept. The methods planned to achieve each objective or task should be discussed explicitly and in detail. This section should be a substantial portion of the total proposal.

f. Related Work. Describe significant activities directly related to the proposed effort, including any conducted by the principal investigator, the proposing firm, consultants, or others. Describe how these activities interface with the proposed project and discuss any planned coordination with outside sources. The proposal must persuade reviewers of the proposer's awareness of the state-of-the-art in the specific topic.

Describe previous work not directly related to the proposed effort but similar. Provide the following: (1) short description, (2) client for which work was performed (including individual to be contacted and phone number), and (3) date of completion.

g. Relationship with Future Research or Research and Development.

(1) State the anticipated results of the proposed approach if the project is successful.
(2) Discuss the significance of the Phase I effort in providing a foundation for Phase II research or research and development effort.

h. Commercialization Strategy. Describe in approximately one page your company's strategy for commercializing this technology in DoD and/or private sector markets. Provide specific information on the market need the technology will address and the size of the market. Also include a schedule showing the quantitative commercialization results from this SBIR project that your company expects to achieve and when (i.e., amount of additional investment, sales revenue, etc. – see items a through g in Section 5.4).

i. Key Personnel. Identify key personnel who will be involved in the Phase I effort including information on directly related education and experience. A concise resume of the principal investigator, including a list of relevant publications (if any), must be included. <u>All resumes will count toward the 25-page limitation.</u>

j. Facilities/Equipment. Describe available instrumentation and physical facilities necessary to carry out the Phase I effort. Items of equipment to be purchased (as detailed in Reference A) shall be justified under this section. Also state whether or not the facilities where the proposed work will be performed meet environmental laws and regulations of federal, state (name), and local Governments for, but not limited to, the following groupings: airborne emissions, waterborne effluents, external radiation levels, outdoor noise, solid and bulk waste disposal practices, and handling and storage of toxic and hazardous materials.

k. Consultants. Involvement of a university or other consultants in the project may be appropriate. If such involvement is intended, it should be described in detail and identified in Reference A. A minimum of <u>two-thirds</u> of the research and/or analytical work in Phase I, as measured by direct and indirect costs, must be carried out by the proposing firm, unless otherwise approved in writing by the contracting officer.

l. Prior, Current, or Pending Support of Similar Proposals or Awards. *Warning* -- While it is permissible, with proposal notification, to submit identical proposals or proposals containing a significant amount of essentially equivalent work for consideration under numerous federal program solicitations, it is unlawful to enter into contracts or grants requiring essentially equivalent effort. If there is any question concerning this, it must be disclosed to the soliciting agency or agencies before award.

If a proposal submitted in response to this solicitation is substantially the same as another proposal that has been funded, is now being funded, or is pending with another Federal Agency or DoD Component or the same DoD Component, the proposer must so indicate on the Proposal Cover Sheet and provide the following information:

(1) Name and address of the Federal Agency(s) or DoD Component to which a proposal was submitted, will be submitted, or from which an award is expected or has been received.
(2) Date of proposal submission or date of award.
(3) Title of proposal.
(4) Name and title of principal investigator for each proposal submitted or award received.
(5) Title, number, and date of solicitation(s) under which the proposal was submitted, will be submitted, or under which award is expected or has been received.
(6) If award was received, state contract number.
(7) Specify the applicable topics for each SBIR proposal submitted or award received.

Note: If Section 3.4.1 does not apply, state in the proposal "No prior, current, or pending support for proposed work."

m. Cost Proposal. Complete the cost proposal in the format shown in Reference A of this solicitation for the Phase I effort only. Some items in Reference A may not apply to the proposed project. If such is the case, there is

no need to provide information on each and every item. What matters is that enough information be provided to allow the DoD Component to understand how the proposer plans to use the requested funds if the contract is awarded.

(1) List all key personnel by name as well as by number on hours dedicated to the project as direct labor.

(2) Special tooling and test equipment and material cost may be included under Phases I and II. The inclusion of equipment and material will be carefully reviewed relative to need and appropriateness for the work proposed. The purchase of special tooling and test equipment must, in the opinion of the Contracting Officer, be advantageous to the Government and should be related directly to the specific topic. These may include such items as innovative instrumentation and/or automatic test equipment. Title to property furnished by the Government or acquired with Government funds will be vested with the DoD Component, unless it is determined that transfer of title to the contractor would be more cost effective than recovery of the equipment by the DoD Component.

(3) Cost for travel funds must be justified and related to the needs of the project.

(4) Cost sharing is permitted for proposals under this solicitation; however, cost sharing is not required nor will it be an evaluation factor in the consideration of a Phase I proposal.

When a proposal is selected for award, the proposer should be prepared to submit further documentation to its DoD contracting officer to substantiate costs (e.g., a brief explanation of cost estimates for equipment, materials, and consultants or subcontractors).

n. Company Commercialization Report on Prior SBIR Awards. If your firm is submitting a Phase I or Phase II proposal, it is required to prepare a Company Commercialization Report through the password-protected DoD Electronic Submission Web Site (http://www.dodsbir.net/submission). If you submit a proposal, you must submit a company commercialization report whether or not you have not previously received SBIR or STTR awards. As instructed on the Web Site, list in the Report the quantitative commercialization results of your firm's prior Phase II projects, including the items listed in section 5.4a through g of this solicitation (sales revenue, additional investment, etc.). The Web Site will then compare these results to the historical averages for the DoD SBIR Program. Once your firm has completed the Report on the Web Site, print out a hard copy of the Report, sign and date it, and attach it to the back of your proposal.

As noted on the Web Site, your firm may also, at its option, include at the end of the Report additional, explanatory material (no more than five pages) relating to the firm's record of commercializing its prior SBIR or STTR projects, such as: commercialization successes (in government and/or private sector markets) that are not fully captured in the quantitative results (e.g. commercialization resulting from your firm's prior Phase I projects); any mitigating factors that could account for low commercialization; and recent changes in the firm's organization or personnel designed to increase the firm's commercialization success. The Company Commercialization Report and additional explanatory material (if any) will not be counted toward the 25-page limit for Phase I proposals.

A Report showing that a firm has received no prior Phase II awards will not affect the firm's ability to obtain an SBIR award.

3.5 Bindings

Do not use special bindings or covers. Staple the pages in the upper left hand corner of each proposal.

3.6 Phase II Proposal Format

This solicitation is for Phase I only. A Phase II proposal can be submitted only by a Phase I awardee and only in response to a request from the agency; that is, Phase II is not initiated by a solicitation.

Each Phase II proposal must contain a Proposal Cover Sheet and a Company Commercialization Report (see Section 3.4b and n). In addition, each Phase II proposal must contain a two-page commercialization strategy, addressing the following questions:

(1) What is the first product that this technology will go into?

(2) Who will be your customers, and what is your estimate of the market size?

(3) How much money will you need to bring the technology to market, and how will you raise that money?

(4) Does your company contain marketing expertise and, if not, how do you intend to bring that expertise into the company?

(5) Who are your competitors, and what is your price and/or quality advantage over your competitors?

The commercialization strategy must also include a schedule showing the quantitative commercialization results from the Phase II project that your company expects to report in its Company Commercialization Report Updates one year after the start of Phase II, at the completion of Phase II, and after the completion of Phase II (i.e., amount of additional investment, sales revenue, etc. – see items a through g in section 5.4).

Additional instructions regarding Phase II proposal preparation and submission will be provided or made available by the DoD Components to all Phase I winners at time of Phase I contract award.

3.7 False Statements

Knowingly and willfully making any false, fictitious, or fraudulent statements or representations may be a felony under the Federal Criminal False Statement Act (18 U.S.C. Sec 1001), punishable by a fine of up to $10,000, up to five years in prison, or both.

4.0 METHOD OF SELECTION AND EVALUATION CRITERIA

4.1 Introduction

Phase I proposals will be evaluated on a competitive basis and will be considered to be binding for six (6) months from the date of closing of this solicitation unless the offeror states otherwise. If selection has not been made prior to the proposal's expiration date, offerors will be requested as to whether or not they want to extend their proposal for an additional period of time. Proposals meeting stated solicitation requirements will be evaluated by scientists or engineers knowledgeable in the topic area. Proposals will be evaluated first on their relevance to the chosen topic. A proposal that meets the goals of a solicitation topic but does not use the exact approach specified in the topic will be considered relevant. (Prospective proposers should contact the topic author as described in Section 1.5 to determine whether submission of such a proposal would be useful.)

Proposals found to be relevant will then be evaluated using the criteria listed in Section 4.2. Final decisions will be made by the DoD Component based upon these criteria and consideration of other factors including possible duplication of other work, and program balance. A DoD Component may elect to fund several or none of the proposed approaches to the same topic. In the evaluation and handling of proposals, every effort will be made to protect the confidentiality of the proposal and any evaluations. There is no commitment by the DoD Components to make any awards on any topic, to make a specific number of awards or to be responsible for any monies expended by the proposer before award of a contract.

For proposals that have been selected for contract award, a Government Contracting Officer will draw up an appropriate contract to be signed by both parties before work begins. Any negotiations that may be necessary will be conducted between the offeror and the Government Contracting Officer. It should be noted that only a duly appointed contracting officer has the authority to enter into a contract on behalf of the U.S. Government.

Phase II proposals will be subject to a technical review process similar to Phase I. Final decisions will be made by DoD Components based upon the scientific and technical evaluations and other factors, including a commitment for Phase III follow-on funding, the possible duplication with other research or research and development, program balance, budget limitations, and the potential of a successful Phase II effort leading to a product of continuing interest to DoD. DoD is not obligated to make any awards under Phase II or the Fast Track, and all awards are subject to the availability of funds. DoD is not responsible for any monies expended by the proposer before award of a contract.

Upon written request and after final award decisions have been announced, a debriefing will be provided to unsuccessful offerors on their proposals (See Section 6.5).

4.2 Evaluation Criteria - Phase I

The DoD Components plan to select for award those proposals offering the best value to the Government and the nation considering the following factors.

a. The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.

b. The qualifications of the proposed principal/key investigators, supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.

c. The potential for commercial (Government or private sector) application and the benefits expected to accrue from this commercialization.

Where technical evaluations are essentially equal in merit, cost to the Government will be considered in determining the successful offeror.

Technical reviewers will base their conclusions only on information contained in the proposal. It cannot be assumed that reviewers are acquainted with the firm or key individuals or any referenced experiments. Relevant supporting data such as journal articles, literature, including Government publications, etc., should be contained or referenced in the proposal and will count toward the 25-page limit.

4.3 Evaluation Criteria - Phase II

The Phase II proposal will be reviewed for overall merit based upon the criteria below.

a. The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.

b. The qualifications of the proposed principal/key investigators, supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.

c. The potential for commercial (Government or private sector) application and the benefits expected to accrue from this commercialization.

The reasonableness of the proposed costs of the effort to be performed will be examined to determine those proposals that offer the best value to the Government. Where technical evaluations are essentially equal in merit, cost to the Government will be considered in determining the successful offeror.

Phase II proposal evaluation may include on-site evaluations of the Phase I effort by Government personnel.

Fast Track Phase II proposals. Under the regular Phase II evaluation process, the above three criteria are each given roughly equal weight (with some variation across the DoD Components). For projects that qualify for the Fast Track (as discussed in Section 4.5), DoD will evaluate the Phase II proposals under a separate, expedited process in

accordance with the above criteria, and may select these proposals for Phase II award provided:

(1) they meet or exceed criteria (a) and (b); and
(2) the project has substantially met its Phase I technical goals

(and assuming budgetary and other programmatic factors are met, as discussed in Section 4.1). Fast Track proposals, having attracted matching cash from an outside investor, presumptively meet criterion (c). Consistent with DoD policy, this process may result in a significantly higher percentage of Fast Track projects obtaining Phase II award than non-Fast Track projects. However, selection and award of a Fast Track proposal is not mandated and DoD retains the discretion not to select or fund any Fast Track proposal.

4.4 Assessing Commercial Potential of Proposals

A Phase I or Phase II proposal's commercial potential will be assessed using the following criteria:

a. The proposer's commercialization strategy (see Sections 3.4h and 3.6) and, as discussed in that strategy: (1) any commitments of additional investment in the technology during Phase II from the private sector, DoD prime contractors, non-SBIR/STTR DoD programs, or other sources, and (2) any Phase III follow-on funding commitments; and

b. The proposer's record of commercializing its prior SBIR and STTR projects, as shown in its Company Commercialization Report (see Section 3.4n). If the "Commercialization Achievement Index" shown on the first page of the Report is at the 5th percentile or below, the proposer will receive no more than half of the evaluation points available under evaluation criterion c in Sections 4.2 and 4.3 ("potential for commercialization"), unless the SBIR program manager for the DoD Component receiving the proposal (Army, Navy, Air Force, etc.) recommends, in writing, that an exception be made for that proposer, and the contracting officer approves the exception.

A Company Commercialization Report showing that the proposing firm has no prior Phase II awards will not affect the firm's ability to win an award. Such a firm's proposal will be evaluated for commercial potential based on its commercialization strategy in item a, above.

4.5 SBIR Fast Track

a. In General. The DoD SBIR program has implemented a streamlined Fast Track process for SBIR projects that attract matching cash from an outside investor for the Phase II SBIR effort (as well as for the interim effort between Phases I and II). The purpose is to focus SBIR funding on those projects that are most likely to be developed into viable new products that DoD and others will buy and that will thereby make a major contribution to U.S. military and/or economic capabilities.

Outside investors, as defined in <u>DoD's Fast Track Guidance</u> (Reference F), may include such entities as another company, a venture capital firm, an individual investor, or a non-SBIR, non-STTR government program; they do not include the owners of the small business, their family members, and/or affiliates of the small business.

As discussed in detail below, projects that obtain matching funds from outside investors and thereby qualify for the SBIR Fast Track will (subject to the qualifications described herein):

(1) Receive interim funding of $30,000 to $50,000 between Phases I and II;
(2) Be evaluated for Phase II award under a separate, expedited process; and
(3) Be selected for Phase II award provided they meet or exceed a threshold of "technically sufficient" and have substantially met their Phase I technical goals (and assuming other programmatic factors are met), as described in Section 4.3.

Consistent with DoD policy, this process should prevent any significant gaps in funding between Phases I and II for Fast Track projects, and result in a significantly higher percentage of Fast Track projects obtaining Phase II award than non-Fast Track projects.

All DoD Components administer the Fast Track according to the procedures in this section, except for BMDO. BMDO administers slightly different procedures that have been approved by the Under Secretary of Defense for Acquisition and Technology – see the BMDO proposal instructions in Section 8 of this solicitation.

b. How To Qualify for the SBIR Fast Track. To qualify for the SBIR Fast Track, a company must submit a Fast Track application within 150 days after the effective start date of its Phase I contract, unless a different deadline for Fast Track applications is specified by the DoD Component funding the project (see the Component's introductory page in Section 8 of this solicitation - the deadlines range from 120 to 180 days). The company is encouraged to discuss the application with its Phase I technical monitor; however, it need not wait for an invitation from the technical monitor to submit either a Fast Track application or a Fast Track Phase II proposal. The awardee should contact their Phase I technical monitor for further instructions and guidance.

A Fast Track application consists of the following items:

(1) A completed Fast Track application form, found at Reference B of this solicitation. On the application form, the company and its outside investor must:
  (a) State that the outside investor will match both interim and Phase II SBIR funding, in cash, contingent on the company's selection for Phase II award, as described on the form at Reference B. The matching rates needed to qualify for the Fast Track are as follows:
    - For companies that have never received a Phase II SBIR award from DoD or any other

federal agency, the minimum matching rate is 25 cents for every SBIR dollar. (For example, if such a company receives interim and Phase II SBIR funding that totals $750,000, it must obtain matching funds from the investor of $187,500.)

- For all other companies, the minimum matching rate is 1 dollar for every SBIR dollar. (For example, if such a company receives interim and Phase II SBIR funding that totals $750,000, it must obtain matching funds from the investor of $750,000.)

(b) Certify that the outside funding proposed in the application qualifies as a "Fast Track investment," and the investor qualifies as an "outside investor," as defined in DoD Fast Track Guidance (Reference F).

(2) A letter from the outside investor to the company, containing:

(a) A commitment to match both interim and Phase II SBIR funding, in cash, contingent on the company's selection for Phase II award, as discussed on the form at Reference B.

(b) A brief statement (less than one page) describing that portion of the effort that the investor will fund. The investor's funds may pay for additional research and development on the company's SBIR project or, alternatively, they may pay for other activities not included in the Phase II contract's statement of work, provided these activities further the development and/or commercialization of the technology (e.g., marketing).

(c) A brief statement (less than one page) describing (i) the investor's experience in evaluating companies' ability to successfully commercialize technology; and (ii) the investor's assessment of the market for this particular SBIR technology, and of the ability of the company to bring this technology to market.

(3) A concise statement of work for the interim SBIR effort (less than four pages) and detailed cost proposal (less than one page). Note: if the company has already negotiated an interim effort (e.g., an "option") of $30,000 to $50,000 with DoD as part of its Phase I contract, it need only cite that section of its contract, and need not submit an additional statement of work and cost proposal.

The company should send its Fast Track application to its Phase I technical monitor, with copies to the appropriate Component program manager and to the DoD SBIR program manager, as indicated on the back of the application form.

Also, in order to qualify for the Fast Track, the company:

(1) Must submit its Phase II proposal within 180 days after the effective start date of its Phase I contract, unless a different deadline for Fast Track Phase II proposals is specified by the DoD Component funding the contract (see the Component's introductory page in Section 8 of this solicitation - the deadlines range from 150 days to 210 days).

(2) Must submit its Phase I final report by the deadline specified in its Phase I contract, but not later than 210 days after the effective start date of the contract (for the Air Force, not later than 270 days).

(3) Must certify, within 45 days after being notified that it has been selected for Phase II award, that the entire amount of the matching funds from the outside investor has been transferred to the company. Certification consists of a letter, signed by both the company and its outside investor, stating that "$______ in cash has been transferred to our company from our outside investor in accord with the SBIR Fast Track procedures." The letter must be sent to the DoD contracting office along with a copy of the company's bank statement showing the funds have been deposited. IMPORTANT: If the DoD contracting office does not receive, within the 45 days, this certification showing the transfer of funds, the company will be ineligible to compete for a Phase II award not only under the Fast Track but also under the regular Phase II competition, unless a specific written exception is granted by the Component's SBIR program manager. Before signing the certification letter, the company and investor should read the cautionary note at Section 3.7. If the outside investor is a non-SBIR/non-STTR DoD program, it must provide a line of accounting within the 45 days that can be accessed immediately.

Failure to meet these conditions in their entirety and within the time frames indicated will generally disqualify a company from participation in the SBIR Fast Track. Deviations from these conditions must be approved in writing by the contracting office.

c. Benefits of Qualifying for the Fast Track. If a project qualifies for the Fast Track:

(1) It will receive interim SBIR funding of $30,000 to $50,000, commencing approximately at the end of Phase I. Consistent with DoD policy, the vast majority of projects that qualify for the Fast Track should receive interim SBIR funding. However, the DoD contracting office has the discretion and authority, in any particular instance, to deny interim funding when doing so is in the Government's interest (e.g., when the project no longer meets a military need or the statement of work does not meet the threshold of "technically sufficient" as described in Section 4.3).

(2) DoD will evaluate the Fast Track Phase II proposal under a separate, expedited process, and may select the proposal for Phase II award provided it meets or exceeds evaluation criteria (a) and (b), as described in Section 4.3 (assuming budgetary and other programmatic factors are met, as discussed in Section 4.1). Consistent with DoD policy, this process should

result in a significantly higher percentage of Fast Track projects obtaining Phase II award than non-Fast Track projects. However, DoD is not obligated, in any particular instance, to award a Phase II contract to a Fast Track project, and DoD is not responsible for any funds expended by the proposer before award of a contract.

(3) It will receive notification, no later than ten weeks after the completion of its Phase I project, of whether it has been selected for a Phase II award.

(4) If selected, it will receive its Phase II award within an average of five months from the completion of its Phase I project.

d. Additional Reporting Requirement. In the company's final Phase II progress report, it must include a brief accounting (in the company's own format) of how the investor's funds were expended to support the project.

5.0 CONTRACTUAL CONSIDERATIONS

Note: Eligibility and Limitation Requirements (Section 1.3) Will Be Enforced

5.1 Awards (Phase I)

a. Number of Phase I Awards. The number of Phase I awards will be consistent with the agency's RDT&E budget, the number of anticipated awards for interim Phase I modifications, and the number of anticipated Phase II contracts. No Phase I contracts will be awarded until all qualified proposals (received in accordance with Section 6.2) on a specific topic have been evaluated. Normally proposers will be notified of selection/non-selection status for a Phase I award within six months of the proposal's closing date.

b. Type of Funding Agreement. All winning proposals will be funded under negotiated contracts and may include a fee or profit. The firm fixed price or cost plus fixed fee type contract will be used for all Phase I projects (see Section 5.5).

c. Average Dollar Value of Awards. DoD Components will make Phase I awards to small businesses typically on a one-half person-year effort over a period generally not to exceed six months (subject to negotiation). P.L. 102-564 allows agencies to award Phase I contracts up to $100,000 without justification. The typical size of award varies across the DoD Components; <u>it is therefore important for a proposer to read the introductory page of the Component to which it is applying (in Section 8.0) for any specific instructions regarding award size</u>.

d. Timing of Phase I Awards. Across DoD, the median time between the date that the SBIR solicitation closes and the award of a Phase I contract is 4 months.

5.2 Awards (Phase II)

a. Number of Phase II Awards. The number of Phase II awards will depend upon the results of the Phase I efforts and the availability of funds. *The DoD Components anticipate that approximately 40 percent of its Phase I awards will result in Phase II projects. This is merely an advisory estimate and the government reserves the right and discretion not to award to any or to award less than this percentage of Phase II projects.*

b. Type of Funding Agreement. Each Phase II proposal selected for award will be funded under a negotiated contract and may include a fee or profit.

c. Average Dollar Value of Awards. Phase II awards will be made to small businesses based on results of the Phase I efforts and the scientific, technical, and commercial merit of the Phase II proposal. Average Phase II awards will typically cover 2 to 5 person-years of effort over a period generally not to exceed 24 months (subject to negotiation). PL 102-564 states that the Phase II awards may be up to $750,000 each without justification. <u>See special instructions for each DoD Component in Section 8.</u>

d. Timing of Phase II Awards. Across DoD, the median time between DoD's receipt of a Phase II proposal and the award of a Phase II contract is 6.5 months

5.3 Phase I Report

a. Content. A final report is required for each Phase I project. The report must contain in detail the project objectives, work performed, results obtained, and estimates of technical feasibility. A completed SF 298, "Report Documentation Page", will be used as the first page of the report. (A blank SF298 is provided in Reference E of this solicitation.) In addition, monthly status and progress reports may be required by the DoD agency.

b. Preparation.

(1) If desirable, language used by the company in its Phase II proposal to report Phase I progress may also be used in the final report.

(2) For each unclassified report, the company submitting the report should fill in block 12a (Distribution/Availability Statement) of the SF298, "Report Documentation Page" with one of the following statements:

(a) Approved for public release; distribution unlimited.

(b) Distribution authorized to U.S. Government Agencies only; contains proprietary information.

Note: The sponsoring DoD activity, after reviewing the company's entry in block 12a, has final responsibility for assigning a distribution statement.

(3) Block 13 (Abstract) of the SF 298, "Report Documentation Page") must include as the first sentence, "<u>Report developed under SBIR contract for topic [insert solicitation topic number]</u>". The abstract must identify the purpose of the work and briefly

describe the work carried out, the finding or results and the potential applications of the effort. Since the abstract will be published by the DoD, it must not contain any proprietary or classified data.

(4) Block 14 (Subject Terms) of the SF 298 must include the term "SBIR Report".

c. Submission. The company shall submit FIVE COPIES of the final report on each Phase I project to the DoD in accordance with the negotiated delivery schedule. Delivery will normally be within thirty days after completion of the Phase I technical effort. The company shall, at the same time, submit ONE ADDITIONAL COPY of each report directly to the DTIC (unless instructed otherwise by the sponsoring DoD activity in the Phase I contract):

ATTN: DTIC-OCA
Defense Technical Information Center
8725 John J Kingman Road, Suite 0944
Ft. Belvoir, VA 22060-6218.

If the report is classified, the sponsoring DoD activity will provide special submission instructions. *Note: The sponsoring DoD activity has final responsibility for ensuring that the company or the DoD activity provide DTIC with all applicable Phase I and Phase II technical reports, classified and unclassified, developed under SBIR contract, per DoD Directive 3200.12 (http://web7.whs.osd.mil/dodiss/directives/direct2.htm).*

5.4 Commercialization Updates in Phase II

If, after completion of Phase I, the contractor is awarded a Phase II contract, the contractor shall be required to periodically update the following commercialization results of the Phase II project through the Web Site at **www.dodsbir.net/submission**:

a. Sales revenue from new products and non-R&D services resulting from the Phase II technology;
b. Additional investment from sources other than the federal SBIR/STTR program in activities that further the development and/or commercialization of the Phase II technology;
c. The portion of additional investment representing clear and verifiable investment in the future commercialization of the technology (i.e., "hard investment");
d. Whether the Phase II technology has been used in a fielded DoD system or acquisition program and, if so, which system or program;
e. The number of patents resulting from the contractor's participation in the SBIR/STTR program;
f. Growth in number of firm employees; and
g. Whether the firm has completed an initial public offering of stock (IPO) resulting, in part, from the Phase II project.

These updates on the project will be required one year after the start of Phase II, at the completion of Phase II, and subsequently when the contractor submits a new SBIR or STTR proposal to DoD. Firms that do not submit a new proposal to DoD will be asked to provide updates on an annual basis after the completion of Phase II.

5.5 Payment Schedule

The specific payment schedule (including payment amounts) for each contract will be incorporated into the contract upon completion of negotiations between the DoD and the successful Phase I or Phase II offeror. Successful offerors may be paid periodically as work progresses in accordance with the negotiated price and payment schedule. Phase I contracts are primarily fixed price contracts, under which monthly payments may be made. The contract may include a separate provision for payment of a fee or profit. Final payment will follow completion of contract performance and acceptance of all work required under the contract. Other types of financial assistance may be available under the contract.

5.6 Markings of Proprietary or Classified Proposal Information

The proposal submitted in response to this solicitation may contain technical and other data which the proposer does not want disclosed to the public or used by the Government for any purpose other than proposal evaluation.

Information contained in unsuccessful proposals will remain the property of the proposer except for the Proposal Cover Sheet. The Government may, however, retain copies of all proposals. Public release of information in any proposal submitted will be subject to existing statutory and regulatory requirements.

If proprietary information is provided by a proposer in a proposal which constitutes a trade secret, proprietary commercial or financial information, confidential personal information or data affecting the national security, it will be treated in confidence, to the extent permitted by law, provided this information is clearly marked by the proposer with the term "PROPRIETARY" and provided that the following legend which appears on the Proposal Cover Sheet (Section 3.4b) of the proposal is completed:

> "For any purpose other than to evaluate the proposal, the data referenced below shall not be disclosed outside the Government and shall not be duplicated, used, or disclosed in whole or in part, provided that if a contract is awarded to the proposer as a result of or in connection with the submission of this data, the Government shall have the right to duplicate, use or disclose the data to the extent provided in the contract. This restriction does not limit the Government's right to use information contained in the data if it is obtained from another source without restriction. The data subject to this restriction is contained on the pages of the proposal listed on the line below."

Any other legend may be unacceptable to the Government and may constitute grounds for removing the proposal from further consideration and without assuming any liability for inadvertent disclosure. The Government

will limit dissemination of properly marked information to within official channels.

In addition, each page of the proposal containing proprietary data which the proposer wishes to restrict must be marked with the following legend:

> "Use or disclosure of the proposal data on lines specifically identified by asterisk (*) are subject to the restriction on the Cover Sheet of this proposal."

If all of the information on a particular page is proprietary, the proposer should so note by including the word "PROPRIETARY" in both the header and footer on that page.

The Government assumes no liability for disclosure or use of unmarked data and may use or disclose such data for any purpose.

In the event properly marked data contained in a proposal in response to this solicitation is requested pursuant to the Freedom of Information Act, 5 USC 552, the proposer will be advised of such request and prior to such release of information will be requested to expeditiously submit to the DoD Component a detailed listing of all information in the proposal which the proposer believes to be exempt from disclosure under the Act. Such action and cooperation on the part of the proposer will ensure that any information released by the DoD Component pursuant to the Act is properly determined.

Those proposers that have a classified facility clearance may submit classified material with their proposal. Any classified material shall be marked and handled in accordance with applicable regulations. Arbitrary and unwarranted use of this restriction is discouraged. Offerors must follow the National Industrial Security Program Operating Manual (NISPOM), DoD 5220.22-M, procedures for marking and handling classified material.

5.7 Copyrights

To the extent permitted by statute, the awardee may copyright (consistent with appropriate national security considerations, if any) material developed with DoD support. DoD receives a royalty-free license for the Federal Government and requires that each publication contain an appropriate acknowledgment and disclaimer statement.

5.8 Patents

Small business firms normally may retain the principal worldwide patent rights to any invention developed with Government support. The Government receives a royalty-free license for its use, reserves the right to require the patent holder to license others in certain limited circumstances, and requires that anyone exclusively licensed to sell the invention in the United States must normally manufacture it domestically. To the extent authorized by 35 USC 205, the Government will not make public any information disclosing a Government-supported invention for a period of five years to allow the awardee to pursue a patent.

5.9 Technical Data Rights

Rights in technical data, including software, developed under the terms of any contract resulting from proposals submitted in response to this solicitation generally remain with the contractor, except that the Government obtains a royalty-free license to use such technical data only for Government purposes during the period commencing with contract award and ending five years after completion of the project under which the data were generated. Upon expiration of the five-year restrictive license, the Government has unlimited rights in the SBIR data. During the license period, the Government may not release or disclose SBIR data to any person other than its support services contractors except: (1) For evaluational purposes; (2) As expressly permitted by the contractor; or (3) A use, release, or disclosure that is necessary for emergency repair or overhaul of items operated by the Government. See DFARS clause 252.227-7018, "Rights in Noncommercial Technical Data and Computer Software -- SBIR Program."

5.10 Cost Sharing

Cost sharing is permitted for proposals under this solicitation; however, cost sharing is not required nor will it be an evaluation factor in the consideration of any Phase I proposal.

5.11 Joint Ventures or Limited Partnerships

Joint ventures and limited partnerships are eligible provided the entity created qualifies as a small business as defined in Section 2.2 of this solicitation.

5.12 Research and Analytical Work

a. For Phase I a minimum of two-thirds of the research and/or analytical work must be performed by the proposing firm unless otherwise approved in writing by the contracting officer.

b. For Phase II a minimum of one-half of the research and/or analytical work must be performed by the proposing firm, unless otherwise approved in writing by the contracting officer.

The percentage of work is usually measured by both direct and indirect costs, although proposers planning to subcontract a significant fraction of their work should verify how it will be measured with their contracting officer during contract negotiations.

5.13 Contractor Commitments

Upon award of a contract, the contractor will be required to make certain legal commitments through acceptance of Government contract clauses in the Phase I contract. The outline that follows is illustrative of the types of provisions required by the Federal Acquisition Regulations that will be included in the Phase I contract. This is not a complete list of provisions to be included in

Phase I contracts, nor does it contain specific wording of these clauses. Copies of complete general provisions will be made available prior to award.

a. Standards of Work. Work performed under the contract must conform to high professional standards.

b. Inspection. Work performed under the contract is subject to Government inspection and evaluation at all reasonable times.

c. Examination of Records. The Comptroller General (or a fully authorized representative) shall have the right to examine any directly pertinent records of the contractor involving transactions related to this contract.

d. Default. The Government may terminate the contract if the contractor fails to perform the work contracted.

e. Termination for Convenience. The contract may be terminated at any time by the Government if it deems termination to be in its best interest, in which case the contractor will be compensated for work performed and for reasonable termination costs.

f. Disputes. Any dispute concerning the contract which cannot be resolved by agreement shall be decided by the contracting officer with right of appeal.

g. Contract Work Hours. The contractor may not require an employee to work more than eight hours a day or forty hours a week unless the employee is compensated accordingly (that is, receives overtime pay).

h. Equal Opportunity. The contractor will not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin.

i. Affirmative Action for Veterans. The contractor will not discriminate against any employee or applicant for employment because he or she is a disabled veteran or veteran of the Vietnam era.

j. Affirmative Action for Handicapped. The contractor will not discriminate against any employee or applicant for employment because he or she is physically or mentally handicapped.

k. Officials Not to Benefit. No member of or delegate to Congress shall benefit from the contract.

l. Covenant Against Contingent Fees. No person or agency has been employed to solicit or secure the contract upon an understanding for compensation except bona fide employees or commercial agencies maintained by the contractor for the purpose of securing business.

m. Gratuities. The contract may be terminated by the Government if any gratuities have been offered to any representative of the Government to secure the contract.

n. Patent Infringement. The contractor shall report each notice or claim of patent infringement based on the performance of the contract.

o. Military Security Requirements. The contractor shall safeguard any classified information associated with the contracted work in accordance with applicable regulations.

p. American Made Equipment and Products. When purchasing equipment or a product under the SBIR funding agreement, purchase only American-made items whenever possible.

5.14 Contractor Registration [NEW]

Before DoD can award a contract to a successful proposer under this solicitation, the proposer must be registered in the DoD Central Contractor Registration database. To register, see http://www.ccr2000.com/ or call 1-888-227-2423.

5.15 Additional Information

a. General. This Program Solicitation is intended for informational purposes and reflects current planning. If there is any inconsistency between the information contained herein and the terms of any resulting <u>SBIR contract</u>, the terms of the contract are controlling.

b. Small Business Data. Before award of an SBIR contract, the Government may request the proposer to submit certain organizational, management, personnel, and financial information to confirm responsibility of the proposer.

c. Proposal Preparation Costs. The Government is not responsible for any monies expended by the proposer before award of any contract.

d. Government Obligations. This Program Solicitation is not an offer by the Government and does not obligate the Government to make any specific number of awards. Also, awards under this program are contingent upon the availability of funds.

e. Unsolicited Proposals. The SBIR Program is not a substitute for existing unsolicited proposal mechanisms. Unsolicited proposals will not be accepted under the SBIR Program in either Phase I or Phase II.

f. Duplication of Work. If an award is made pursuant to a proposal submitted under this Program Solicitation, the contractor will be required to certify that he or she has <u>not previously</u> been, nor is <u>currently</u> being, paid for essentially <u>equivalent work</u> by an agency of the Federal Government.

g. Classified Proposals. If classified work is proposed or classified information is involved, the offeror to the solicitation must have, or obtain, security clearance in

accordance with the National Industrial Security Program Operating Manual (NISPOM), DoD 5220.22-M. The manual is available on-line at **http://www.dss.mil** or in hard copy from:

Defense Security Service (DSS)
1340 Braddock Place
Alexandria, VA 22314
Phone: (703) 325-5324

6.0 SUBMISSION OF PROPOSALS

An original plus (4) copies of each proposal or modification will be submitted, in a single package, as described below, unless otherwise stated by specific instructions in Section 8.0.

NOTE: EACH PROPOSAL MUST CONTAIN A COMPLETED PROPOSAL COVER SHEET AND COMPANY COMMERCIALIZATION REPORT (see Section 3.4b and n).

6.1 Address

Each proposal or modification thereof shall be submitted in sealed envelopes or packages addressed to that DoD Component address which is identified for the specific topic in that Component's subsection of Section 8.0 to this solicitation.

The name and address of the offeror, the solicitation number, the topic number for the proposal, and the time and date specified for proposal receipt must be clearly marked on the outside of the envelope or package. To protect your proposal against rough handling, damage in the mail, and the possibility of unauthorized disclosures, it is recommended that your proposal be double-wrapped and that both the inner and outer envelopes or wrappings be clearly marked.

Offerors using commercial carrier services shall ensure that the proposal is addressed and marked on the outermost envelope or wrapper as prescribed above.

Mailed or hand carried proposals must be delivered to the address indicated for each topic. Secured packaging is mandatory. The DoD Component cannot be responsible for the processing of proposals damaged in transit.

All copies of a proposal must be sent in the same package. Do not send separate <u>information</u> copies or several packages containing parts of the single proposal.

6.2 Deadline of Proposals

Deadline for receipt of proposals at the DoD Component is 3:00 p.m. local time, January 16, 2002. Any proposal received at the office designated in the solicitation after the exact time specified for receipt will not be considered unless it is received before an award is made, and:

(a) it was sent by registered or certified mail not later than January 9, 2002.

(b) it was sent by mail or hand-carried (including delivery by a commercial carrier) and it is determined by the Government that the late receipt was due primarily to Government mishandling after receipt at the Government installation; or

(c) it was sent by U.S. Postal Service Express Mail Next Day Service-Post Office to Addressee, not later than 5:00 p.m. at the place of mailing on January 15, 2002.

Note: <u>There are no other provisions for late receipt of proposals under this solicitation.</u>

The only acceptable evidence to establish the date of mailing of a late proposal sent either by registered or certified mail is the U. S. Postal Service postmark on the envelope or wrapper and on the original receipt from the U.S. Postal Service. Both postmarks must show a legible date or the proposal shall be processed as if mailed late. "Postmark" means a printed, stamped, or otherwise placed impression (exclusive of a postage meter machine impression) that is readily identifiable without further action as having been supplied and affixed by employees of the U. S. Postal Service on the date of mailing. Therefore, offerors or respondents should request the postal clerk to place a legible hand cancellation bull's-eye postmark on both the receipt and the envelope or wrapper. Acceptable evidence to establish the time of receipt at the Government installation includes the time/date stamp of the installation on the proposal wrapper, other documentary evidence of receipt maintained by the installation, or oral testimony or statements of Government personnel. The only acceptable evidence to establish the date of mailing of a late proposal sent by Express Mail Next Day Service-Post Office to Addressee is the date entered by the post office receiving clerk on the "Express Mail Next Day Service-Post Office to Addressee" label and the postmark on both the envelope or wrapper and on the original receipt from the U.S. Postal Service. Therefore, offerors should request the postal clerk to place a legible hand cancellation bull's eye postmark on both the receipt and the envelope or wrapper.

Proposals may be withdrawn by written notice or a telegram received at any time prior to award. Proposals may also be withdrawn in person by an offeror or his authorized representative, provided his identity is made known and he signs a receipt for the proposal. *(Note: the term <u>telegram</u> includes mailgrams.)*

Any modification or withdrawal of a proposal is subject to the same conditions outlined above. Any modification may not make the proposal longer than 25 pages (excluding Company Commercialization Report). Notwithstanding the above, a late modification of an otherwise successful proposal which makes its terms more favorable to the Government will be considered at any time it is received and may be accepted.

6.3 Notification of Proposal Receipt

Proposers desiring notification of receipt of their proposal must complete and include a self-addressed stamped envelope and a copy of the notification form (Reference C) in the back of this brochure. If multiple proposals are submitted, a separate form and envelope is required for each. Notification of receipt of a proposal by the Government does not by itself constitute a determination that the proposal was received on time or not. The determination of timeliness is solely governed by the criteria set forth in Section 6.2.

6.4 Information on Proposal Status

Evaluation of proposals and award of contracts will be expedited, but no information on proposal status will be available until the final selection is made. However, contracting officers may contact any and all qualified proposers prior to contract award.

6.5 Debriefing of Unsuccessful Offerors

An unsuccessful offeror that submits a written request for a debriefing within 30 days of being notified that its proposal was not selected for award will be provided a debriefing. The written request should be sent to the DoD organization that provided such notification to the offeror. Be advised that an offeror that fails to submit a timely request is not entitled to a debriefing, although untimely debriefing requests may be accommodated at the Government's discretion.

6.6 Correspondence Relating to Proposals

All correspondence relating to proposals should cite the SBIR solicitation number and specific topic number and should be addressed to the DoD Component whose address is associated with the specific topic number.

7.0 SCIENTIFIC AND TECHNICAL INFORMATION ASSISTANCE

7.1 DoD Technical Information Services Available

The Defense Technical Information Center (DTIC) provides background technical information services at no cost, which can assist SBIR/STTR participants in proposal preparation, product development, marketing and networking.

The DTIC SBIR/STTR web site provides the following free services at **http://www.dtic.mil/dtic/sbir**:

1. Public STINET and Web Enabled DROLS (WED): Access DTIC's online technical databases including 37,000 plus full-text downloadable documents.

2. OLTIPS has bibliographies for each DoD SBIR and STTR topic

3. Technical Reports: Up to ten hard copy technical reports are available at no cost from DTIC during an SBIR, or a combined SBIR/STTR, solicitation period. Additional reports can be charged to a credit card or deposit account.

4. TRAIL: provides biweekly listings of new DTIC accessions matching the recipient's interests

5. SITIS: Interactive question and answer forum for specific technical questions concerning DoD topics, changes, and topic reference information.

DTIC is a major component of the DoD Scientific and Technical Information Program, making available technical information resulting from DoD-funded research and development **(http://www.dtic.mil).** DTIC also provides access to specialized information services. MATRIS is the focal point for information on manpower, training systems, human performance, and human factors **(http://dticam.dtic.mil).** The Information Analysis Centers (IACs) are the DoD centers of expertise concerned with engineering, technical and scientific documents and databases worldwide **(http://www.dtic.mil/iac/).**

Call DTIC (or visit by prearrangement at the location most convenient to you).

ATTN: DTIC-SBIR
Defense Technical Information Center
8725 John J Kingman Road, Suite 0944
Ft. Belvoir, VA 22060-6218
Ph: (800) 363-7247
Fax: (703) 767-8228
Email: sbir@dtic.mil
www: http://www.dtic.mil/dtic/sbir

ATTN: DTIC-BPB
DTIC Northeastern Regional Office
DTIC-BOS
5 Wright Street
Hanscom AFB
Bedford, MA 01731-3012
Ph: (781) 377-2413
Fax: (781) 377-5627
Email: boston@dtic.mil

DTIC Southwestern Regional Office
ATTN: DTIC-BRNA
AFRL/VSIL/DTIC
3550 Aberdeen Ave, SE
Kirtland AFB, NM 87117-5776
Ph: (505) 846-6797
Fax: (505) 846-6799
Email: albuq@dtic.mil

ATTN: DTIC-BPD
DTIC Midwestern Regional Office
Bldg. 196, Area B
2261 Monahan Way
Wright-Patterson AFB, OH 45433-7022
Ph: (937) 255-7905
Fax: (937) 656-7002
Email: dayton@dtic.mil

ATTN: DTIC-BPL
DTIC Western Regional Office
Bldg. 80
2420 Vela Way, Suite 1467
El Segundo, CA 90245-4659
Ph: (310) 363-8980
Fax: (310) 363-8972
Email: losangel@dtic.mil

7.2 Other Technical Information Assistance Sources

Other sources provide technology search and/or document services and can be contacted directly for service and cost information. These include:

National Technical Information Services
5285 Port Royal Road
Springfield, VA 22161
Ph: (703) 605-6000 or (800) 553-6847
Fax: (703) 605-6900
Email:info@ntis.fedworld.gov
www: www.ntis.gov

University of Southern California
Office of Patents and Copyright Administration
3716 South Hope Street, Suite 313
Los Angeles, CA 90007-4344
Ph: (213) 743-2282
Fax: (213) 744-1832
www: www.usc.edu/academe/otl

Center for Technology Commercialization
1400 Computer Drive
Westborough, MA 01581-5043
Ph: (508) 870-0042
Fax: (508) 366-0101
www: www.ctc.org

Great Lakes Technology Transfer Center/Battelle
25000 Great Northern Corporate Center, Suite 260
Cleveland, OH 44070
Ph: (440) 734-0094
Fax: (440) 734-0686
www: www.battelle.org/glitec/

Midcontinent Technology Transfer Center
Texas Engineering Extension Service
The Texas A&M University System
301 Tarrow
College Station, TX 77843-8000
Ph: (979) 845-2907
Fax: (979) 845-3559
www: www.teexweb.tamu.edu/tedd

Mid-Atlantic Technology Applications Center
University of Pittsburgh
3400 Forbes Avenue
Pittsburgh, PA 15260
Ph: (412) 383-2500
Fax: (412) 383-2595
www: www.mtac.pitt.edu

Southern Technology Application Center
University of Florida
1900 SW 34th Street, Suite 206
Gainesville, FL 32608-1260
Ph: (352) 294-7822
Fax: (352) 294-7802
www: www.state.fl.us/stac/

Federal Information Exchange, Inc.
555 Quince Orchard Road, Suite 360
Gaithersburg, MD 20878
Ph: (301) 975-0103
Ph: (800) 875-2562
Fax: (301) 975-0109
www: www.rams-fie.com

7.3 DoD Counseling Assistance Available

Small business firms interested in participating in the SBIR Program may seek general administrative guidance from small and disadvantaged business utilization specialists located in various Defense Contract Management activities throughout the continental United States. These specialists are available to discuss general administrative requirements to facilitate the submission of proposals and ease the entry of the small high technology business into the Department of Defense marketplace. The small and disadvantaged business utilization specialists are expressly prohibited from taking any action which would give an offeror an unfair advantage over others, such as discussing or explaining the technical requirements of the solicitation, writing or discussing technical or cost proposals, estimating cost or any other actions which are the offerors responsibility as outlined in this solicitation. (See Reference D at the end of this solicitation for a complete listing, with telephone numbers, of Small and Disadvantaged Business Utilization Specialists assigned to these activities.)

7.4 State Assistance Available

Many states have established programs to provide services to those small firms and individuals wishing to participate in the Federal SBIR Program. These services vary from state to state, but may include:
- Information and technical assistance;
- Matching funds to SBIR recipients;
- Assistance in obtaining Phase III funding.

Contact your State Government Office of Economic Development for further information.

8.0 TECHNICAL TOPICS

Section 8 contains detailed topic descriptions outlining the technical areas in which DoD Components request proposals for innovative R&D from small businesses. Topics for each participating DoD Component are listed and numbered separately. At least 20 percent of the Navy, Air Force, and Chemical Biological Defense topics either are authored by a DoD acquisition program (e.g., New Attack Submarine, Abrams Tank) or are of significant interest to such a program, as noted in the text of the topic. These acquisition programs are potentially important end customers for innovative new products resulting from SBIR projects. Information on how to contact these programs is posted on the DoD SBIR/STTR Web Site (http://www.acq.osd.mil/sadbu/sbir/acqprog/liaisons.htm).

Each DoD Component Topic Section contains topic descriptions, addresses of organizations to which proposals are to be submitted, and special instructions for preparing and submitting proposals to organizations within the Component. Read and follow these instructions carefully to help avoid administrative rejection of your proposal.

Many of the topics in Section 8 contain references to technical literature or military standards, which may be accessed as follows:

- References with "AD" numbers are available from DTIC, by calling 800/DoD-SBIR or sending an e-mail message to sbir@dtic.mil, or using the Document Request form at http://www.dtic.mil/dtic/sbir/service_req.html. Newer reports may be available for download after searching http://stinet.dtic.mil.
- References with "MIL-STD" numbers are available from the Department of Defense Single Stock Part for Military Specifications, Standards, and Related Publications at http://www.dodssp.daps.mil (or using the DTIC STINET interface at http://stinet.dtic.mil/str/dodiss4_fields.html.
- Other references can be found in your local library or at locations mentioned in the reference. Check SITIS for additional availability information.

CHEMICAL AND BIOLOGICAL DEFENSE PROGRAM

General Information

In response to Congressional interest in the readiness and effectiveness of U.S. Nuclear, Biological and Chemical (NBC) warfare defenses, Title XVII of the National Defense Authorization Act for Fiscal Year 1994 (Public Law 103-160) required the Department of Defense (DoD) to consolidate management and oversight of the Chemical and Biological Defense (CBD) Program into a single office within the Office of the Secretary of Defense. The public law also directed the Secretary of Defense designate the Army as the Executive Agent for coordination and integration of the CBD Program. The executive agent for the Small Business Innovation Research (SBIR) portion of the program is the Army Research Office-Washington (ARO-W).

The objective of the DoD CBD Program is to enable U.S. forces to survive, fight and win in chemical and biological warfare environments. Numerous rapidly-changing factors continually influence the program and its management. These forces include declining DoD resources, planning for warfighting support to numerous regional threat contingencies, the evolving geopolitical environment resulting from the breakup of the Soviet Union, U.S. participation in the Chemical Weapons Convention, and the continuing global proliferation of chemical and biological weapons. Improved defensive capabilities are essential in order to minimize the impact of such weapons. U.S. forces require aggressive, realistic training and the finest equipment available that allows them to avoid contamination, if possible, and to protect, decontaminate and sustain operations throughout the non-linear battlespace. Further information about the DoD CBD Program (and related programs) is available at the DoD Counterproliferation and Chemical Biological Defense Homepage at Internet address http://www.acq.osd.mil/cp/.

The overall objective of the CBD SBIR Program is to improve the transition or transfer of innovative CBD technologies between DoD components and the private sector for mutual benefit. The CBD SBIR Program includes those technology efforts that maximize a strong defensive posture in a biological or chemical environment using passive and active means as deterrents. These technologies include chemical and biological detection; information assessment, which includes identification, modeling and intelligence; contamination avoidance; and protection of both individual warfighters and equipment.

Tri-Service Program

The U.S. Army, Navy, Air Force, and SOCOM have developed separate SBIR topics for research and development in various CBD areas of interest. As lead agency, the Army will coordinate efforts related to the receipt, evaluation, selection, and award of Phase I proposals and similarly for potential follow-on Phase II efforts under this program.

Submitting Your Phase I CBD SBIR Proposal

The CBD SBIR Program now requires that a proposing firm have Internet access via the World Wide Web, in order to submit its Phase I CBD SBIR proposal – in its entirety – online. <u>You must also submit an original and two copies via mail or other delivery means (See 3. Postal Submission below)</u>. Please review and follow these procedures when submitting each Phase I proposal:

1. Online Submission: The entire proposal including all forms must be submitted via the Internet. Go to the DoD SBIR proposal submission site (URL address: <u>http://www.dodsbir.net/submission/</u>) which will lead you through the preparation of the following proposal sections:

   a. Proposal Cover Sheet Pages (Firm information and project abstract)
   b. Cost Proposal (Must use online form provided)
   c. Technical Proposal (File upload via submission site)
   d. Company Commercialization Report (Does not count against 25 page limit)

2. Acceptable Formats for Technical Proposal Upload: All technical proposal files will be converted to Portable Document Format (PDF) for evaluation purposes. Acceptable formats (PC/Windows) are: MS Word, WordPerfect, PDF, Text, and Rich Text Format (RTF). The Technical Proposal should include all graphics and attachments, conform to the limitations on margins and number of pages, and exactly reflect the hardcopy version. <u>Offerors are responsible for performing a virus check on each submitted Technical Proposal</u>. Each submitted electronic technical proposal will be scanned for viruses. The detection of a virus on any submitted electronic Technical Proposal may cause rejection of the proposal.

3. Postal Submission: Postal submission includes an original signed proposal with all forms and required attachments, plus two copies. All proposals written in response to topics in this solicitation must be received by the date and time indicated in Section 6.2 of the introduction to this solicitation. Offerors are advised to submit proposal(s) well before the deadline. **Late proposals will not be accepted.**

All Phase I proposals - one original (clearly marked, with original signatures) and two copies - must be submitted to the CBD SBIR Program Management Office at the address below. Each copy must include the Technical Proposal, signed Proposal Cover Pages, signed Cost Proposal and the signed Company Commercialization Report. All hand deliveries must be made to the Army Materiel Command (AMC) building mail room, located at the rear of the AMC building. Proposers should be aware that the AMC mail room hours are 0730-1530 hrs (local) and are subject to change without prior notice. *Offerors using non-government courier services assume the risk for late delivery of proposals.

Mail proposals to:
Dr. Kenneth A. Bannister
U.S. Army Research Office-Washington
Room 8N31, Army Materiel Command Building
5001 Eisenhower Avenue
Alexandria, VA 22333-0001
(703) 617-7425

Please Note: Potential offerors must follow the proposal content rules for the agency which has proponency for topics. Topics are numbered in series, with Army topics starting at 100, Navy topics starting at 200, Air Force topics starting at 300, and SOCOM topics starting at 400. Detailed instructions for proposals to be submitted against Army topics are given below. Refer to the appropriate Navy, Air Force, and SOCOM sections in this Solicitation for information on how to prepare proposals for submission against Navy, Air Force, and SOCOM CBD SBIR topics.

Army Proposal Guidelines

The Army has enhanced its Phase I-Phase II transition process by implementing the use of a Phase I Option that the Army may exercise to fund interim Phase II activities while a Phase II contract is being negotiated. The maximum dollar amount for a Phase I feasibility study is $70,000. The Phase I Option, which **must** be proposed as part of the Phase I proposal, covers activities over a period of up to four months and at a cost not to exceed $50,000. All proposed Phase I Options must be fully costed and should describe appropriate initial Phase II activities which would lead, in the event of a Phase II award, to the successful demonstration of a product or technology. **The Army will not accept Phase I proposals which exceed $70,000 for the Phase I effort and $50,000 for the Phase I Option effort**. Only those Phase I efforts selected for Phase II awards through the Army's competitive process will be eligible to exercise the Phase I Option. To maintain the total cost for SBIR Phase I and Phase II activities at a limit of $850,000, the total funding amount available for Phase II activities under a resulting Phase II contract will be $730,000.

Companies submitting a Phase I proposal to the Army under this Solicitation must complete the Cost Proposal within a total cost of $70,000 (plus up to $50,000 for the Phase I Option). Phase I and Phase I Option costs must be shown separately; however, they may be presented side-by-side on a single Cost Proposal. The Phase I Option proposal must be included within the 25-page limit for the Phase I proposal. In addition, all offerors will prepare a Company Commercialization Report, for each proposal submitted, which does not count toward the 25-page limitation.

Selection of Phase I proposals will be based upon scientific and technical merit, according to the evaluation procedures and criteria discussed in this solicitation document. Due to limited funding, the Army reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality will be funded.

Proposals not conforming to the terms of this solicitation, and unsolicited proposals, will not be considered. Awards are subject to the availability of funding and successful completion of contract negotiations.

Army Phase II Proposal Guidelines

CBD SBIR Phase II proposals are invited by the individual Service or SOCOM from CBD SBIR Phase I projects that have demonstrated the potential for commercialization of useful products and services. The invitation will be issued by the Service organization or SOCOM personnel responsible for the Phase I effort. Invited proposers are required to develop and submit a commercialization plan describing feasible approaches for marketing the developed technology. Fast Track participants may submit a proposal without being invited. Cost-sharing arrangements in support of Phase II projects and any future

commercialization efforts are strongly encouraged, as are matching funds from independent third-party investors, per the SBIR Fast Track Program (see section 4.5). Commercialization plans, cost-sharing provisions, and matching funds from investors will be considered in the evaluation and selection process, and Fast Track proposals will be evaluated under the Fast Track standard discussed in section 4.3. Phase II proposers are required to submit a budget for a base year (first 12 months) and an option year. These costs must be submitted using a Cost Proposal, and may be presented side-by-side on a single Cost Proposal Sheet. The total proposed amount should be indicated on the Proposal Cover Page, Proposed Cost. Phase II projects will be evaluated after the base year prior to extending funding for the option year.

The Army is committed to minimizing the funding gap between Phase I and Phase II activities. With the implementation of Phase I Options, all Army Phase II proposals will receive expedited reviews and be eligible for interim funding. Accordingly, all Army Phase II proposals, including Fast Track submissions, will be evaluated within a single evaluation schedule.

Key Dates

02.1 Solicitation Open	1 December 2001 – 16 January 2002
Phase I Evaluations	**January - March 2002**
Phase I Selections	March 2002
Phase I Awards	May 2002
Fast Track Applications Due	September 2002
Phase II Invitations	September 2002
Phase II Proposals Due	October 2002

PROPOSAL CHECKLIST

This is a Checklist of Requirements for your proposal. Please review the checklist carefully to assure that your proposal meets the Army CBD SBIR requirements. **Failure to meet these requirements will result in your proposal not being considered for review or award**. Do not include this checklist with your proposal.

______1. The proposal cost adheres to the individual Service (Army, Navy, Air Force) or SOCOM criteria specified.

_____ 2. The proposal is limited to only **ONE** solicitation topic. All required documentation within the proposal references the same topic number.

_____ 3. The proposal, including the Proposal Cover Sheets and Cost Proposal, is 25 pages or less in length. (Excluding the Company Commercialization Report.) Proposals in excess of this length will not be considered for review or award.

_____4. The entire proposal including all forms must be submitted via the Internet using the DoD's SBIR Proposal Submission System which can be accessed at URL address: http://www.dodsbir.net/submission/.

_____ 5. The Proposal Cover Sheet and the Project Summary Sheet, are the first two pages of your proposal. The Proposal Cover Pages clearly show the proposal number assigned by the system to your proposal and is signed. The Project Abstract contains no proprietary information, does not exceed 200 words, and is limited to the space provided. The Cost Proposal is complete, signed, and is included as the last section of the proposal. (For Army topics the **Phase I and Phase I Option** costs must be shown separately on the Cost Proposal).

_____ 6. The Company Commercialization Report, is submitted in accordance with Section 3.4.n. This report will be signed and is required even if the company has not received any SBIR funding. (This report does not count towards the 25-page limit)

_____7. The proposal contains only pages of 8-1/2" X 11" size. No other attachments such as disks, and videotapes are included. The proposal contains no type smaller than 11-point font size (except as legend on reduced drawings, but not tables). The proposal is stapled in the upper-left-hand corner and no special binding or covers are used.

_____8. An original with original signatures as required **(clearly marked)** and two copies of the proposal are submitted. The proposal must be sent registered or certified mail, postmarked by January 9, 2002, or delivered to the Army SBIR Program Management Office no later than **January 16, 2002, 3:00 p.m. local time** as required (see Section 6.2). Offerors who elect to use commercial courier services do so at their own risk. The Army **cannot** accept responsibility for proposals delivered late by commercial couriers.

_____9. Include a self-addressed, stamped envelope and a copy of the Notification Form (Reference A) located in the back of the solicitation book, if notification of proposal receipt is desired. **No responses will be provided if these are not included with your proposal.**

INDEX OF CHEMICAL AND BIOLOGICAL DEFENSE 02.1 TOPICS

Army CBD SBIR Topics

CBD02-100	Molecular Signatures of Biological Pathogens
CBD02-101	Automated Preferential Display of Genes of Unknown Sequences
CBD02-102	Smokes Originating from Biological Materials
CBD02-103	Chemical Protective Gloves with Enhanced Properties
CBD02-104	Remote Surface Contamination Sensor
CBD02-105	Novel Conjugation Sites for Antigen Binding Reagents
CBD02-106	Improved Field Biosensor for Organophosphates

Navy CBD SBIR Topics

CBD02-200	Destruction of Chemical and Biological Agents and Hazardous Medical Waste Using a Hybrid Microwave System
CBD02-201	Diver Worn Equipment for Diving in Chemical/Biological, Toxic Industrial Chemical and Toxic Industrial Material (TIC/TIM)
CBD02-202	Improved System and Methods for Evaluating Protective Material Performance to Chemical Agents
CBD02-203	Multi-TIC Colormetric Badge
CBD02-204	Modular Environmental Situational Awareness Technology

Air Force CBD SBIR Topics

CBD02-300	Miniaturized Real-time Visible/UV Spectrometer
CBD02-301	Exploitation of Quantum Well Interactions for Electro-optical Sensor Development
CBD02-302	Reactive Functionality in Fabrics and Protective Coatings
CBD02-303	Improved Filters for Chemical Warfare Agent Detectors
CBD02-304	Enhanced Biorecognition Reagent System
CBD02-305	Residual Life Indicator for Advanced/Regenerable Air Filters
CBD02-306	Establish a Non-aqueous Non-flammable and Non-corrosive Decontamination Process for Aircraft Cargo Interior

Special Operations Command (SOCOM) CBD SBIR Topics

CBD02-400	Hand-held, Standoff Chemical-Biological Hazard Detector

CHEMICAL AND BIOLOGICAL DEFENSE 02.1 TOPIC DESCRIPTIONS

ARMY CBD SBIR TOPICS

CBD02-100 TITLE: Molecular Signatures of Biological Pathogens

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: To identify and characterize genetic responses to pathogen exposure at a genome level. To identify early molecular markers of biological agent exposure. To develop a database of human responses to various pathogens so that exposure can be determined and the agent can be accurately identified within minutes or hours of contact. To enable extremely rapid and accurate identification of human exposure to infectious pathogens and biological warfare agents, so that appropriate countermeasures can be administered, and the effects of the biological agent can be decimated or neutralized.

DESCRIPTION: Exposure of humans to pathogens has been demonstrated to be detectable within hours of contact by measuring gene expression levels on a genomic scale (i.e. using microarray chips). While this technology has been shown to be capable of much earlier detection of exposure than traditional methods, at present the human genomics databases are insufficient to diagnose which pathogen a person was exposed to. Research is needed to develop a database of the human genomic response to various pathogens. Development of such a database will allow medical personnel to use very small amounts (less than a drop) of bodily fluids (urine, blood, sputum, sweat, or nasal swabs) to detect and diagnose exposure to an infectious agent. Such early detection of pathogen exposure would allow medical personnel to administer countermeasures before the pathogen has reached levels high enough to cause an effect. Eventually, this technology could be used in extremely small units that would take tiny samples painlessly and automatically, and continually monitor warfighter exposure to biological warfare and infectious disease agents. The threat of biological warfare agents would thus be almost eliminated, and sick time due to transmission of infectious diseases would be greatly reduced.

PHASE I: The investigators will identify a group of individuals from whom they can take very small fluid samples frequently (such as twice a day). This group should be relatively young, healthy, and reflect the genetic diversity of the U.S. Armed Forces. The investigators will take fluid samples from the entire group at regular intervals and store the samples. The investigators will choose one class of infectious pathogen to which exposure is readily available (such as rhinoviruses). When the volunteers develop the infection, the pathogen will be isolated and its identity determined. Fluid samples from that volunteer will be assayed using microarray chips. Enough pre-exposure samples will be examined to establish the individual variability in gene expression. Samples from the individual who developed the infection will also be examined from the time of exposure to the time of maximum illness. The successful phase I project will identify the genetic responses of human exposure to the particular pathogen examined. The noise generated by daily variation within individuals and individual to individual variation will be known. The investigators will identify which genes alter gene expression levels in response to this class of pathogens, and the genetic responses will be classified by the number of hours after exposure that they occur. A rigorous statistical framework will be in place so that the accuracy of the diagnosis is known.

PHASE II: The investigators will expand their research to investigate multiple types of pathogens, including bacterial, viral, and fungal. The investigators will generate a database of human responses to the various types of pathogens, and demonstrate that this database can be used to identify pathogen exposure within hours of the exposure. In addition, the investigators will demonstrate that the pathogen or class of pathogen can be identified by the pattern of genes that alter their expression levels. Pathogen diagnosis by genomic profiling will be confirmed by standard laboratory procedures to culture and identify microorganisms. Accuracy of the identified patterns of gene expression will be confirmed by assaying blind samples. The investigators will build a prototype for a selected pathogen, which could be used as the basis for a phase III commercial product.

PHASE III DUAL USE APPLICATIONS: It is anticipated that this database will lead to a microarray chip that will have broad applications in medical diagnosis of infectious diseases. The second generation of such chips could be targeted to identifying the molecular signals preceding medical conditions such as stroke, and other medical conditions not caused by infectious diseases.

REFERENCES:

1. Blader IJ, Manger ID, Boothroyd JC. Microarray analysis reveals previously unknown changes in toxoplasma gondii infected human cells. J Biol Chem. 2001 Apr 9 (epub).
2. Kurella M, Hsiao LL, Yoshida T, Randall JD, Chow G, Sarang SS, Jensen RV, Gullans SR. DNA microarray analysis of complex biologic processes. J Am Soc Nephrol. 2001 May;12(5):1072-8.
3. Maeda S, Otsuka M, Hirata Y, Mitsuno Y, Yoshida H, Shiratori Y, Masuho Y, Muramatsu Ma, Seki N, Omata M. cDNA Microarray Analysis of Helicobacter pylori-Mediated Alteration of Gene Expression in Gastric Cancer Cells. Biochem Biophys Res Commun. 2001 Jun 8;284(2):443-9.
4. Manger ID, Relman DA. How the host 'sees' pathogens: global gene expression responses to infection.

5. Curr Opin Immunol. 2000 Apr;12(2):215-8.

KEYWORDS: Microarrays, Genomics, Chips, Pathogens

CBD02-101 TITLE: Automated Preferential Display of Genes of Unknown Sequences

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: Develop an integrated, automated, miniature method of detecting unique gnees and their level of expression without a prior knowledge of gene sequences.

DESCRIPTION: A variety of methods and technologies are available for detection of unique genes from a complex pool of gene sequences. However, almost all of these methods possess two major problems. These methods do not selectively display unique sequences. All gene sequences are amplified and presented (with the exception of subtractive hybridization-based methods). It is estimated that redundant sequences account for approximately 94% of all genes expressed using current display technologies [1]. Thus, large numbers of genes are displayed resulting in expenditure of much time and resources in identification of redundant sequences. Secondly, these methods are tedious and expensive involving use of sophisticated instrumentation and conventional gel electrophoretic methods. There is a need for development of a platform technology capable of selective detection of unique genes from a complex pool of genes without requiring the use of conventional electrophoretic methods, perhaps fluorescence-based and easily amenable to automation and miniaturization. Sequencing of the approximately 30,000 genes in the human genome, and the sequencing of complete pathogen genomes, combined with microarray technology and the power of bioinformatics, have resulted in the development of gene arrays (a.k.a. gene chips) with a variety of important applications. Such arrays measure the relative expression of thousands of genes and have tremendous promise for detection and identification of biological agents, including genetically modified organisms. The single greatest rate-limiting factor in fully exploiting these technologies is the current inability to consistently immobilize the biological materials on glass and silicon substrates, a problem which will be complicated by next generation chip materials such as titanium alloys. Such a technology will not only allow rapid detection of 'stealth' pathogens and/or genetically engineered pathogens without requiring prior knowledge of the gene sequences but also aid in determining the effects of low dose exposure to toxic agents at the gene level.

PHASE I: Develop and validate a method/protocol for 'selective' screening and detection of unique genes without requiring prior knowledge of the gene sequences. The method should be relatively simple, requiring minimal skilled user intervention, amenable to single tube reaction mixture and/or miniaturization and ideally suited for use with high throughput gene expression analytical applications. Identify current and future chip materials, the immobilization processes commonly used genes, oligonucleotides and proteins, and the quality of current array manufacturing processes.

PHASE II: Present day differential gene expression analysis methods such as Differential Display [2], Subtractive Hybridization [3], RNA-arbitrary primed PCR (RAP-PCR) [4], Representative Difference Analysis (RDA) [5], Serial Analysis of Gene Expression (SAGE) [6,7,8] screen for unknown differentially expressed genes. However, they are not amenable to miniaturization and when carried out at the bench require sophisticated and expensive instrumentation. Most of these technologies require bench top elaborate mRNA isolation schemes, thermocyclers, hybridization chambers, electrophoresis and fluorescent scanner/imaging apparatus. Such applications are not only expensive but also impractical for high throughput purposes. Development of an integrated high throughput system for automated gene detection of unknown sequence is highly desirable and will require identification of manufacturing issues and proposed solutions to address accuracy, precision, reliability and cost. Microarray techniques are powerful approaches, however, their usage is often limited largely by the challenge of data management and analysis [9]. Such a technology can dramatically decrease the number of genes to be analyzed and data to be handled by selective expression of only expressed genes. Front-end integration of selection and presentation of preferentially expressed genes to microarrays developed by Affymetrix, Incyte, NEN, Clontech, etc. is also desirable.

Deliver reagents, final protocols and data validated with standard gene expression analysis methods along with identified unique gene sequences from the targets of interest. Protocols using fluorescence-based analysis are highly desirable. High throughput automation with miniaturization on a microchip level or single tube reaction is required in Phase II. Phase II deliverables should also include any high throughput system developed, a microchip and/or any other consumables necessary for performing the assay. Development of a method that can measure the level of gene expression is also highly desirable.

PHASE III DUAL USE APPLICATIONS: Such a technology will provide for the pharmaceutical industry a very simple and accurate pharmacogenomic method to evaluate new drug effectiveness, isolation of novel sequences for diagnostic applications, discovery of disease and treatment motifs, and reduction of the expense of medical treatments and hospitalization. It will substantially lower the cost and time in the drug development cycle by affording a more accurate drug target validation, minimizing toxic effects in the drug discovery process and reducing time to market of these drugs. The technology will also have

widespread application in assessing the effects of toxicants at the level of gene expression and would serve as a high throughput toxicology screen which would replace animals.

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KEYWORDS: Gene Expression, Gene Sequencing, Pathogen Detection, Bioforensics, Toxicogenomics, Microarrays, Genomics

CBD02-102 TITLE: Smokes Originating From Biological Materials

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: To design, test and develop military smokes that originate from biological systems. To take advantage of the natural ability of biological systems to produce biodegradable or environmentally innocuous particles via molecular assembly or self-assembly into tailorable monodisperse distributions.

DESCRIPTION: The US Army has a continuing need for improved materials for smoke and obscuration. The core figure of merit for smoke materials is the extinction coefficient in the radiation band of interest and central to any improved material is an elevated extinction coefficient. However extinction is not the only area in which improvements are possible and desired. Improvements in the environmental impact, toxicological and other safety aspects of battlefield and training smokes are becoming increasingly important, particular with the increasing potential for urban scenarios. Biologically derived materials will show considerable improvement over inventory in these safety and environmental areas.

The current high interest area for improved materials is the infrared region, particularly in the 3-5 and 8-14 micron wavelength bands. For this application ideal materials are submicron to nanoscale particles with a generally flake- or disk-like shape with high aspect ratio (diameter:thickness) and significant electrical conductivity (equal to or greater than graphite). The secondary interest is "multispectral" screening ranging from the visible or near-infrared to the millimeter range. For these applications a desirable particle would be a submicron fiber, again with high aspect ratio (length:diameter) and conductivity. More details on the theoretically ideal are available in the references. More recent theoretical work has been completed but has not yet been published. The results of this work indicate that the ideal particles are either fibers which are 20nm in diameter by 4 microns in length made of materials with electrical conductivity at least 105 mho/cm or flakes which are 4 microns in diameter by 0.8nm thick with conductivity in the same range. There are quite a number of approaches to applying biological systems to this problem. To suggest a few as seeds for thought: Biotic or biomimetic particles chosen specifically for size and shape characteristics and monodispersity could be treated or coated to provide conductivity. In this case, the dimensions described above for ideal materials apply specifically to the coating dimensions. Biological systems could be engineered for controllable generation of particulates. Biological macromolecules could be investigated to use the microwave activity observed by Davis and Edwards. Self assembly of macromolecules could be devised to produce appropriate particles or coar particle with appropriate conductive layers. Bacteria, for instance, magnetotactic strains, could be engineered to generate particles.

The smoke and obscurant characterization capabilities at the Edgewood Chemical Biological Center (ECBC) would be made available to provide laboratory demonstration and to provide data that are directly comparable to an existing extensive database of smoke material characteristics. This would be at no cost to the SBIR contractor. Additional issues to be considered in devising smoke materials are deagglomeration, aerosolization, achievable packing density, cost and weight. In the realm of nanoparticles, deagglomeration and aerosolization are particularly challenging issues.

PHASE I: During Phase I initial materials will be developed and evaluated in any form convenient considering the manufacture process. Materials sufficient for evaluation will be provided to ECBC. These may be either dispersed in liquid at a known concentration (10ml quantities), provided as powder for liquid dispersal (100mg quantities) or provided in powder form suitable for aerosolization through gas nozzles (10g quantities). The goal of phase I will be to prove feasibility of improved smoke through biology by achieving extinction coefficients as good or better than current inventory materials and to show initial progress toward making significant improvements over inventory smokes.

PHASE II: Phase II will address the more challenging aspects of manufacture scale-up, control of aggregation and agglomeration, and aerosolization. The goal of phase II will be to demonstrate a smoke of biological origin that provides a factor of 4 improvement over inventory smokes and is proven suitable for aerosolization and scale-up manufacture.

PHASE III DUAL USE APPLICATIONS: Although the application of obscuration is specific to the military, the overall areas of nanoparticles and interactions between the biological and mineral worlds at the nanoscale are not. Technology developed in these areas have applications in antiviral and antibacterial activity, nanophase structural materials, and chemical and biological sensors based on the unique properties of materials in the realm between quantum and microscopic.

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KEYWORDS: Obscuration, Attenuation, Biotics, Biomimetics, Particles, Nanoparticles, Fiber, Flake, Extinction, Infrared, Millimeter, Electromagnetic Radiation

CBD02-103 TITLE: Chemical Protective Gloves with Enhanced Properties

TECHNOLOGY AREAS: Chemical/Bio Defense

ACQUISITION PROGRAM: Program Manager - Soldier Equipment

OBJECTIVE: Explore nanoscale phenomena to develop novel materials and a solvent less process for the manufacture of tactile, durable, flame retardant, solvent resistant gloves impermeable to liquid chemical warfare (CW) agents.

DESCRIPTION: The 7-, 14-, and 25-mil-thick chemical protective gloves currently used by the military are made of butyl rubber reinforced with carbon black [1]. They are produced by a solvent dipping process. The gloves are neither resistant to petroleum-type solvents, oils and lubricants nor to flames. However, they show excellent resistance to liquid CW agents and to oxygenated-type solvents. With the incorporation of inorganic nanoparticles into select polymers, it may be possible to improve their resistance to CW agents and at the same time take advantage of their other features, such as good resistance to solvents, abrasion and aging. It has been shown that inorganic nanoparticles dispersed in a polymeric matrix have a tendency to form layers through its thickness, thus enhance barrier properties of polymers [2]. Moreover, the inorganic nature of these nanoparticles and their intumescent properties may impart flame resistance and thus eliminate the need for adding flame retardant chemicals into formulations [3]. Furthermore, these new materials should be amenable to solvent less processing techniques, such as injection molding, blow molding, spraying/sintering, or aqueous/emulsion dipping.

PHASE I: Select candidate polymers and fabricate glove materials in the laboratory. Determine pertinent physical and mechanical properties, and also resistance to permeation by CW agents.

PHASE II: Optimize the best candidate materials selected in Phase I. Develop a cost effective, non-polluting, solvent less process for the manufacture of gloves. Produce gloves in 7-, 14-, 25-, and 35-mil thickness for laboratory testing and field evaluation.

PHASE III DUAL USE APPLICATIONS: Butyl gloves are widely used in industrial applications. Improvements either in properties of materials, such as flame retardancy and abrasion resistance, or process, which would lower the volatile organic compounds (VOC) content, will readily find commercial acceptance. Other potential commercial applications for materials containing nanoparticles include coatings for tentage and for special purpose protective suits needed for domestic preparedness activities.

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KEYWORDS: Gloves, Elastomers, Polymers, Nanomaterials, Nanoparticles, Chemical Protection

CBD02-104 TITLE: Remote Surface Contamination Sensor

TECHNOLOGY AREAS: Chemical/Bio Defense

ACQUISITION PROGRAM: Nuclear, Biological, and Chemical Reconnaissance Systems

OBJECTIVE: Demonstrate proof of principal of an optical technology for remote (one or more meters) detection of contamination (oil, chemical, fuel) on solid surfaces.

DESCRIPTION: One of the more significant threats to combat systems is the potential for enemy use of a persistent chemical warfare agent. The common persistent agents such as the nerve agent VX are characterized by very low vapor pressure, thus presenting a contact as opposed to a vapor hazard. These agents can be employed to deny key terrain and avenues of approach, or interfere with airfields and logistics systems. Once such an agent is deployed, detection becomes difficult. Current Defense Department Nuclear, Biological, and Chemical (NBC) reconnaissance systems employ contact sensors to detect and identify contaminants on surfaces, obligating the reconnaissance system to become contaminated itself in the process of monitoring and marking the limits of contamination. Optical methods for the detection of contamination on surfaces, although technically quite challenging, are not unheard of.. Infrared spectroscopy can be useful in the identification of chemical materials on surfaces by providing vibrational spectral information. However, the introduction of Reststrahlen effects makes the effective use of reflectance spectroscopy for unambiguous identification impractical. Nevertheless, some information may still be extracted from the infrared reflectance data using, e.g., the Kubelka-Munk formalism (1948). The Reststrahlen bands themselves are often employed in the identification of minerals (see for example Bower, 1998). The Diffuse Reflectance Infrared Fourier Transform Spectroscopy (DRIFTS) technique, though optimized for the study of powders, has been applied to trace quantities of liquids adsorbed onto solid surfaces (Fuller and Griffiths, 1978).

The Kubelka-Munk, Reststrahlen, and DRIFTS approaches cited here should be taken as potential approaches for the solution of the surface contamination detection problem. This solicitation is open to any innovative application of an optical technique for surface contamination monitoring (e.g., Raman LIDAR, laser-induced breakdown, and vapor generation by remote heating with subsequent IR sensing of the vapor spectra).

PHASE I: Demonstrate, through rigorous theoretical modeling and controlled laboratory data, the proof of principal of the proposed solution. Construct preliminary library of surface properties accessible by the technique and describe suitable algorithm for automation of the sensor technology.

PHASE II: Construct a prototype optical sensor and integrate signal acquisition and analysis for autonomous alarm operation

PHASE III DUAL USE APPLICATIONS: Outfit Defense Department Nuclear, Biological, and Chemical (NBC) reconnaissance systems with a forward-looking contamination detector. Commercialize and market a surface or soil contamination monitor for industrial and environmental applications including engineering reactor cleaning, hazardous spill remediation, and land reclamation.

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KEYWORDS: Surface Contamination, Optical Reflectance, Differential Albedo, Diffuse Reflectance, Reststrahlen, Kubelka-Munk, Light Detection and Ranging (LIDAR), Laser-Induced Breakdown Spectroscopy (LIBS)

CBD02-105 TITLE: Novel Conjugation Sites for Antigen Binding Reagents

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: Development of novel conjugation sites for next generation recombinant antibody and nucleic acid reagents.

DESCRIPTION: Fully characterized, standardized and validated reagents (antibodies, antigens, and gene primers/probes) are critical for the detection and identification of Biological Warfare (BW) agents. For Biosensors use, immunoglobulins (IgG) are easily and routinely modified by attachment of reporter molecules to conjugation sites (amines and sulfhydryl groups). While recombinant antibodies [antibody binding fragments (Fab'), single chain fragments (scFv)], RNA ligands (aptamers) and peptides possess antigen binding sites, conjugation sites are frequently eliminated and would require reengineering to add new conjugation sites. In addition, the placement of reengineered conjugation sites is critical to avoid steric hindrance of the antigen binding site due to the small size of the reagents. This may be resolved by the addition of chemical spacer arms (tethers) that separate the detector molecule from the reagent antigen binding site. Additionally, selective chemical placement of reporter molecules (enzymes, lanthanides, heavy metal chelates, and fluorophores) commonly used as reporter molecules is not a straightforward science known to most end-users and is not optimized for sensitivity and steric hindrance avoidance. We propose research in conjugation chemistry which addresses the following:

-development of novel conjugation sites for attachment of reporter molecules on engineered antigen-binding molecules
-development of novel chemical spacer arms to separate the antigen binding site from the reporter molecules

PHASE I: Identification of new conjugation chemistry/spacer arm techniques with successful testing for antigen binding and stability on an engineered antigen-binding molecule.

PHASE II: Test successful Phase I techniques on recombinant antibodies, aptamers and peptides. Tailor reagents where necessary to attach to a variety of substrates, such as glass, paramagnetic beads and titanium alloys. Compare reagents against current antibody-based systems for improved sensitivity and cost savings. Development of large scale "kit" for labeling reagents.

PHASE III DUAL USE APPLICATIONS: Adapt and test labeled reagents in biosensors including DoD diagnostic hand-held assays, sensors for industrial process control and medical diagnostics.

KEYWORDS: Conjugation Chemistry, Biosensors, Reporter Molecules, Antibody

CBD02-106 TITLE: Improved Field Biosensor for Organophosphates

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: The objective is to design, develop, and produce a versatile personal biosensor or badge for detecting organophosphates (OPs). The badge must overcome limitations of the current sensors (M272 and M256A1 kits and the M18A3 nerve agent detection ticket) for testing G and V agents in any environment. While current kits can detect OPs only in air or a drop of liquid, they cannot be used for sampling water and soil. Additionally, it is advantageous if the badge/biosensor could provide a qualitative indication of the type of OP in the field in real-time. The ability to identify the G or V agent in the field would aid in treatment, in securing the contaminated area, and in the identification of illegal use of OPs. The badges must provide sensitivity and selectivity, limit false readings, and therefore consist of immobilized or enduring enzymes to prevent leaching to the environment. Lastly, the badge must be lightweight, and require no energy source for qualitative results or require minimal power (a battery for up to several months) using hand-held optical units.

DESCRIPTION: The US Joint Services, Federal Agencies, and state and local First Responders are currently using the M256A1 kit to detect G and V agents. Although the M256A1 kit has performed well and meets US Army requirements, numerous shortcomings have been identified through feedback from military and agency users. There are several criteria for a viable biosensor suitable for field deployment. The sensor must have a size, weight, and power consumption that is small and in a hand-held electronic unit, use for months without battery exchange, yet be rugged if it is to be a personal kit. The sensor must overcome human factors; at the very least, be easy to use. The detector must sense all the OPs to which the human enzyme is sensitive, yet be selective for OP compounds or pesticides. Enzyme sensors have had the advantage of selectivity, sensitivity and, most important, specificity, ease and portability, and markedly simplified instrumentation. Biosensors of enzyme can behave as a dosimeter, accumulating only those OP inhibitors demonstrating exquisite selectivity for the specific enzyme, while ignoring other environmental interferences. Enzymes act as very rapid biological amplifiers. The unit must have a low false rate, respond in a rapid manner, and function under diverse conditions such as in the night. The badge must be sensitive to a wide variety of test conditions, for example, determining whether drinking water, air, soil, or the general environment, or a soldier's clothes and equipment have become contaminated with OPs. The unit must have a long and stable shelf life. A significant advantage would

be field identification of the specific OP chemical warfare agent, which might be accomplished by using multiple differentiating enzymes.

PHASE I: Phase I research will be restricted to showing feasibility of producing biosensors that could readily replace current G and V agent components in the M256A1 and M272 kits, while meeting the criteria of detecting the agents in diverse environmental conditions, including water and soil, i.e., overcoming the shortcomings of current kits. This means that the enzyme(s) must not leak from the detector. In addition, the improved/modified biosensors must be designed to meet/exceed other current M256A specifications (that meet feasibility testing during this short time frame), such as accelerated stability testing to ensure a long shelf life of the new product. Considerable innovation is required to develop enzymes that can function in harsh environments and not leach from the substrate matrix.

PHASE II: Define and develop detection schemes for identification of the type of G or V agent that might be present in the field, consistent with the criteria of Phase 1. The biosensor could be composed of different enzymes, producing qualitative colorimetric changes and/or placed in a hand-held spectrophotometers with built-in intelligence so the rates of inhibition of AChE, BChE, and other suitable enzymes could be directly determined. Complete studies demonstrating that the biosensor meets/exceeds M256A1 and M272 specifications for G and V agents including sensitivity, aging, interference, user evaluation, blank response tests, sensitivity tests, etc. Substantial innovation is required to develop a scheme of procedures/enzymes to differentially indicate in the field the specific G or V agent(s) while meeting the requirements described in Phase 1. Live agents will be required to test the biosensor; possible sources for testing include industrial (Battelle) and academic laboratories permitted to use the G and V agents.

PHASE III DUAL USE APPLICATIONS: (1) Produce biosensors, including differential sensor, for replacement of current kits used in the military and civilian use to be incorporated into current kits with as little re-engineering as possible. (2) Prepare a hand-held version so that information could be transmitted to a central facility to monitor for toxic OP clouds or the transportation of OPs in water. Participate in dual civilian use (e.g., First Responder testing).

A) There must be a rapid and effective means to determine potential OPs that might occur from a terrorist act if first responders are to effectively contain the chemical agents. It is important that there be a civilian field unit capable of rapid qualitative detection of OP contamination in water, skin, and other surfaces. A quantitative method should also be available for monitoring exposure in the field, i.e., a hand-held unit. The ability to identify the OP toxin in the field and confirmation in the lab would aid in treatment and securing any contaminated area. B) An inexpensive OP sensor could be used to monitor exposure (immediate and long term) to pesticides in the field. This is of particular importance since there is increasing use of and poisoning by pesticides. C) Biosensors composed of human or other suitable cholinesterases, which would provide these detection sensors with the same sensitivity to organophosphates as human beings, could be a home product to ensure food free of pesticides.

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KEYWORDS: Biosensor, Enzymes, Cholinesterases, Organophosphorus Hydrolases, Phosphotriesterases, Organophosphorus Chemical Warfare Agents, Pesticides, Terrorist, First Responders

NAVY CBD SBIR TOPICS

CBD02-200 TITLE: Destruction of Chemical and Biological Agents and Hazardous Medical Waste using a Hybrid Microwave System

TECHNOLOGY AREAS: Chemical/Bio Defense

ACQUISITION PROGRAM: Program Manager, Marine and Nuclear, Biological, and Chemical Defense Equipment

OBJECTIVE: To evaluate the potential of microwave energy as a potential method to destroy chemical & biological agents and medical waste. Basic research at NASA, the DOE Savannah River Site, and in private sector labs in Japan / Europe have explored the potential to use microwave energy as an efficient waste destruction method. Some of this research utilized microwave energy as a waste destruction and disinfection mechanism while other work explored the treatment of the off-gases produced in the destruction process. Because of the wide range of materials associated with chemical and biological agents and medical waste streams, before scaled-up prototype systems are built from the current exploratory work, the need exists for an evaluation process and small scale testing, perhaps utilizing data modeling systems, to determine if microwave energy could indeed provide the destructive ability to treat these chemical and biological waste streams in an efficient manner.

DESCRIPTION: Chemical and biological agents are being stockpiled in a variety of sites and the threat of facing such agents in warfare presents a significant concern to the health and safety of military and civilian personnel and the environment. Concern is growing over the safe disposal of existing chem-bio stockpiled materials and how to also safely process the materials that are required to produce, handle, and store them. Contamination can come from the chem-bio agents themselves and also from all equipment and materials used to produce, handle, and transport them. This equipment can include everything from personal protection gear (face shields, gloves, suits, shoes, etc.) to maintenance equipment used to contain or absorb contaminated liquid material (mops, containers, plastic draping, duct tape, etc.) DoD identified need centers on an ability to dispose of chemical and biological warfare materials in ways that pose the least risk to military and civilian personnel and the environment.

DoD currently utilizes a complex system of incineration (kiln) systems with associated scrubbers to ensure emissions are within regulatory guidelines and to render harmless chemical and biological agents. These incinerators are under increasing scrutiny from local and federal environmental regulatory agencies, and restrictions on their level of emissions continue to increase. In addition, the complexity of their operation makes them expensive to operate and increases the likelihood of frequent equipment malfunction or failure. Further, current disposal processes pose threats to the safety and health of operators and maintenance personnel because of their exposure to sharps and biological material in the transport, operation, and disposal steps. In addition, current kiln systems are not suitable for field/portable operation. Because of the potential of facing chemical and biological agents in a real engagement somewhere in the world, the ideal treatment system would be portable, allowing destruction of materials at the point of origin, rather than requiring expensive and high-risk transport back to the U.S. Such issues give rise to alternative technologies.

There is a corresponding private sector need that exhibits many of the same dangers of processing, handling, transport, and disposal seen in the DoD chem-bio challenge. Infectious medical waste can pose a serious biological threat by exposing health care professionals and maintenance personnel to materials that may contain bloodborne pathogens (such as the hepatitis B virus and HIV/AIDS virus). Correspondingly, significant volume of medical waste is also generated at most military installations and onboard ships as well. The nation's 6,323 hospitals generate an estimated four billion pounds of medical waste annually.

As is seen in the chem-bio arena, the medical waste risk is present in the actual pathogens but these pathogens also contaminate the materials that are used for personal protection, handling, transport, and disposal. These medical-related materials include blood-exposure components (plastic IV bags, needles, syringes, lancets, and scalpels) but also personal infection control products such as caps, gowns, face masks, latex gloves, and surgical drapes.

There are two primary disposal methods of choice that are currently used to handle medical waste: (a) incineration and (b) landfilling. Both disposal methods expose health care and sanitation workers to infectious material, and incineration emits

significant environmental pollutants to the general population. The environmental threat of medical waste incineration was reflected in the August 19, 1997 Environmental Protection Agency (EPA) Final Rulemaking (Code of Federal Regulations, 40 CFR, Part 60) which will severely restrict incineration of medical waste and close down 80-95% of such facilities in this country. This regulatory mandate outlines limits for particulate matter, carbon dioxide, dioxins and furans, hydrogen chloride, sulfur dioxide, nitrogen oxides, lead, cadmium, and mercury.

The need exists for an innovative technology that will treat a wide range of chemical and biological material, eliminate its threat to human health, and perform this function in a manner that does not pose significant risks to human or environment health and safety. Microwave energy may provide this solution but early-stage evaluations must be conducted to see if this field warrants additional exploration and development. The proposed testing will assemble the targeted waste streams and materials in the chemical, biological and medical waste fields and assess the theoretical potential of microwave energy to destroy the waste and reduce its environmental impact.

PHASE I: The work conducted under Phase I of the proposed research would establish the credibility that indeed microwave energy could be viewed as a viable destruction and effluent treatment system. Due to the known array of liquids and solids in the chemical and biological defense field and the range of medical waste materials (plastics, glass, metals, paper, tissue, nonwovens) encountered in both the military and commercial sectors, the candidate system must demonstrate an ability to accept and treat a wide range of components to be considered a viable alternative technology to existing methods of destruction. This will mean treating actual or simulated wastes to determine the potential feasibility and flexibility of such a system. In addition, the configuration of such a system must also be proposed. In some of the early stage experiments in Japan, industrial-sized microwaves are envisioned while other work at DOE suggests smaller, point-of-origin systems that could be used at a DoD base or in the case of medical waste, at a clinic or operating room.

The throughput capacity and economics of the proposed system must be evaluated to be seen as a viable alternative. Potentially, microwave modeling techniques may be employed to provide an early-stage confirmation of the potential for microwave energy to be considered a viable waste destruction alternative.

PHASE II: From this applied research and preliminary technology development in Phase I will come the creation of a working, scaled-up prototype in Phase II of the SBIR. An actual working system would be devised and built. Actual chemical and biological agents and targeted waste materials would be introduced into the system and its destruction and off-gas treatment capabilities would be assessed. Key considerations would be its ability to destroy a significant (75%+) volume of the material, eliminate any hazardous or infectious potential, and produce waste gases that are well within known federal standards for such treatment applications. Temperature measurements will be taken within the microwave heating area to determine if the 5x decontamination level of FM3-5 can be attained for chemical agent destruction.

PHASE III DUAL USE APPLICATIONS: From the development of a working prototype in Phase II will come key learning about the performance of the system and how to modify it to achieve the cleanest, most cost efficient destruction process. This learning will allow the installation of a beta test unit into (a) military installation and (b) a private sector medical center where its performance can be monitored in actual use situations.

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KEYWORDS: Chemical, Biological, Hybrid, Microwave Energy, Waste Destruction, Contamination

CBD02-201 TITLE: Diver Worn Equipment for Diving in Chemical/Biological, Toxic Industrial Chemical and Toxic Industrial Material (TIC/TIM)

TECHNOLOGY AREAS: Chemical/Bio Defense, Human Systems

OBJECTIVE: To develop diver worn equipment suitable for protecting a diver receiving breathing air from a surface supplied source while diving and working in chemical, biological, toxic industrial chemical, toxic industrial material (TIC/TIM), and chemical warfare agent (CWA) contaminated environments.

DESCRIPTION: Worldwide, water conditions have become increasingly more dangerous to both military and commercial divers due to chemical, biological, toxic industrial chemical, toxic industrial material (TIC/TIM) and potential chemical warfare agent (CWA) contamination. Additionally, with stringent regulations governing personnel exposures, the need exists for an improved surface supplied diver worn system that will prevent the exposure of the working diver to these contaminated environments while fulfilling the mission. Recent developments in diving helmet design have demonstrated the feasibility of significantly improving the breathing gas/water interface performance capabilities and the ability to keep contamination in the surrounding water from entering the helmet.

PHASE I: Develop and demonstrate a conceptual demand regulator and exhaust valve system for demand type diving helmets, in particular the underwater breathing apparatus (UBA) MK 21 MOD 1/Superlite 17B, when used in water contaminated with chemical, biological, TIC/TIM and CWA contaminated environments. Contaminants to be considered include flammable liquids such as hydrocarbons (petroleum products, benzene, ethers, ketones), oxidizing agents such as halogens and acids, biological agents such as raw sewage and its derivatives such as pfisteria and e-coli bacteria, antifouling paints such as tributyltin (TBT), creosote, and traditional chemical/biological agents such as GB (sarin), GD (suman), HD (mustard), and VX. The regulator, exhaust valve and their component materials must be impermeable to and not degraded by the subject contaminants for the mission period, usually 4-6 hours. The contractor shall conduct laboratory evaluations to demonstrate that the conceptual regulator and exhaust valve do not permit the simulated contaminants to enter the helmet or breathing loop. Performance of the breathing regulator and flow of breathing gas through the breathing loop must not be degraded from current performance levels.

PHASE II: Refine conceptual demand regulator and exhaust valve systems and integrate into the UBA MK 21 MOD 1 diving helmet. Conduct laboratory evaluations of the modified helmet to demonstrate that it's work of breathing has not increased over current levels. Evaluation should also show that the chemical and biological agent simulants do not penetrate the helmet/breathing loop environment for the entire mission period regardless of the work level. Independent chemical testing shall be conducted of regulator and exhaust valve components to demonstrate that there is no degradation or permeation of the components for the full mission period. Conduct an assessment of CWA/TIC/TIM vulnerabilities of the UBA MK 21 helmet and identify and validate methods for "hardening" the helmet prior to contamination. Determine and verify materials and methodology for decontaminating the helmet after contamination.

PHASE III DUAL USE APPLICATIONS: Provide a final product consisting of a UBA MK 21 MOD 1 diving helmet with fully demonstrated and documented demand regulator and exhaust valve for contaminated water diving. Conduct testing with helmet connected to Navy approved dry suits with integral neck dam to demonstrate integrity of the entire diver protective environment. The final product should include procedures for chemically hardening the helmet and helmet/suit interface prior to diving in a contaminated environment and procedures for decontamination of the helmet after contamination.

This new product will significantly improve safety for commercial divers working in hazardous waters. Up to ninety percent (90%) of the surface-supplied diving helmets used by commercial oil and salvage divers in the United States are the same as those used by the U.S. Armed Forces. These particular helmets are the standard in the industry.

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5. Failure Modes, Effects, and Criticality Analysis of the MK-12 Diving Helmet for Contaminated Water Diving Application, TRI Report #11, Task Order 0003
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KEYWORDS: Contaminated, Water, Chemical/Biological, Toxic, TIC/TIM, Diving, Helmet, Surface-Supplied, CWA

CBD02-202 TITLE: Improved System and Methods for Evaluating Protective Material Performance to Chemical Agents

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes, Human Systems

OBJECTIVE: To develop a system that can effectively test the permeability of clothing materials to chemical warfare agents under a variety of simulated real-life scenarios. The system should be safe, efficient (allowing maximization of test throughput), reliable, relatively inexpensive, and capable of providing real-time data over a wide range of analyte concentrations. The final product will be a laboratory test system and methodology that will allow the delivery of agent under defined test conditions, perform real-time assays, and present data in a usable form. Information generated from this system will be useful to: materials manufacturers who, through the analysis of real time permeation kinetics can better understand the mechanisms of breakthrough and ultimately develop better products and end-users to determine the safety limits of various materials employed in protective garb for the battlefield.

DESCRIPTION: The use of chemical warfare agents on the battlefield has become a highly visible issue in recent years. Currently, the number of nations possessing a chemical warfare capability is increasing, as is the possibility that members of the U.S. military may suffer exposure to chemical agents on the battlefield. A major element in the protective ensemble is a protective garment that is impermeable to chemical warfare agents. This can only be made possible through effective engineering, fabrication and testing of the component materials of the uniform and then finally the testing of the uniform configuration and design.

Current testing systems rely on relatively antiquated "wet chemistry" assays which are expensive, labor intensive, and do not allow acquisition of real-time breakthrough data. The kinetic profile of agent permeation is not presently attainable. In addition, test set-up is currently performed by human technicians hand delivering dangerous agents without the aid of robotics. Current systems allow little variation in testing environment. The proposed system will allow testing without any of the above obstacles. Specifically, a variety of agent delivery modes (liquid, droplet, gaseous) will be accommodated and a number of environmental conditions will be precisely controlled (temperature, relative humidity, flow rate, contaminants).

PHASE I: The contractor shall design and demonstrate a system that can provide environmental control (temperature, relative humidity, presence of "contaminants"); allow safe analyte challenge through liquid, aerosolized droplet, and gaseous exposure; allow multiple materials samples to be tested simultaneously; and allow real-time chemical assay with the capability to process the sensor signals and provide "user friendly" breakthrough data. The contractor should demonstrate the potential of the system to address the present needs with "simulant agent tests".

PHASE II: The contractor shall finalize system designs and develop a fully functional prototype that addresses the challenge, testing, sensing, and processing requirements described above. The contractor shall demonstrate improved materials testing system performance by virtue of live chemical agent testing in parallel with existing systems and methods. All live agent testing will by a currently approved surety laboratory.

PHASE III DUAL USE APPLICATIONS: The final product will be a fully integrated, tested, and verified materials testing system capable of providing real-time, quantitative chemical permeation performance. The system will have advanced the field of materials testing by: offering more realistic and diverse test scenarios to be tested; improving testing controls and methodologies; reducing testing logistics and costs; and, most importantly, providing real-time insight to material performance to chemical agents. The implications of this system would be far reaching and ultimately provide improved systems and an improved level of safety for troops. The system benefits could be extended to serve non-military material industries and provide an improved quality of life to millions of users of chemical protective products.

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KEYWORDS: Chemical Agent, Chemical Protection, Materials Testing, Sensors, Nuclear, Biological, and Chemical Survivability

CBD02-203 TITLE: Multi-TIC Colormetric Badge

TECHNOLOGY AREAS: Chemical/Bio Defense, Human Systems

ACQUISITION PROGRAM: ACAT IV: Program Manager MARINE Nuclear, Biological, and Chemical, Combat Supoort Logistics Equipment (CSLE)

OBJECTIVE: To develop a light-weight, wearable device for detecting and alerting the wearer of low level exposure to Chemical Warfare Agents (CWA) and high priority Toxic Industrial Compounds (TICs).

DESCRIPTION: Challenges faced by the military while operating in a chemically threatened environment are compounded by the inability to rapidly and accurately detect low-level exposure to CWAs and select TICs. This topic seeks the development of a wearable monitor that can act as a personal alarm for individual soldiers who may be required to operate in these environments. The Military currently addresses chemical agent threats with area and point detection systems, protective clothing, masks and medical care (1). The sensitivity of the area and point detection systems are limited and can be compromised by chemical aromatics and other common compounds often present in a battlefield. These devices work well as gross level detection devices. However, they are not currently designed as personal low level exposure alarms. Additionally, the performance of protective clothing and masks can be compromised by wear and tear as well as misuse. Individual exposures to low concentrations of CWAs may cause cumulative effects, could temporarily or permanently cause harm or even death. (2). A personal chemical monitor that alerts the wearer when he/she has been exposed to a CWA at concentrations less than the Immediately Dangerous to Life and Health (IDLH) level would greatly improve the safety and fighting capabilities of our armed forces. The chemical monitor will be particularly useful to Special Forces war-fighters who often find themselves in solitary environments where support personnel and equipment is generally not available.

The sensor needs to be compact and lightweight, unobtrusive, easy to use and maintain, field rugged, stable in all operating environments, able to be worn with clothing or personal protective equipment (PPE), require no environmental protection (i.e., special storage) and must provide rapid accurate detection with a low false alarm rate. As an objective capability, the sensor must datalog time, temperature, humidity, agent type and concentration, and sensor status for subsequent download. Sensor indications and controls must be night vision compatible. Sensor alarms must incorporate silent alarm techniques and adjustable audible alarms.

PHASE I: In this period the contractor is to demonstrate proof-of-concept of a potentially successful approach for the sensor used in the monitor CWAs and TICs. "Innovative" or "creative" approaches to meeting the technical goals should be demonstrated to indicate that the proposed concept can provide the basis for a successful program.

PHASE II: It is expected that in this period a working prototype of the complete monitor will be available. The prototype should contain the essential features of the envisioned final product. Testing for sensitivity, specificity, stability, and logistics supportability will be conducted. Considerable innovation will be required to improve the sensitivity and selectivity classic and emerging CWAs and TIC while maintaining confidence and a low false alarm rate.

PHASE III DUAL USE APPLICATIONS: Produce sufficient quantities to allow independent testing, operational assessment, and transition to ongoing joint or service specific programs. In the commercial sector, it will provide protective measures for safety personnel fighting a terrorist chemical attack; for law enforcement personnel who investigate chemically compromised urban environments; and for manufacturers and handlers of pesticides and fertilizers, such as agricultural workers.

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5. Operational Requirements Document for the Joint Modular Chemical/Biological Detection System (JMCBDS) Revised Final Draft, 20 July 2000, JTD: J2U003-I

KEYWORDS: Colormetric Badge, Chemical Warfare Agents, Toxic Industrial Compounds, Wearable Monitor, Personal Protective Equipment

CBD02-204 TITLE: Modular Environmental Situational Awareness Technology

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: NAVSEA 05R: Operational Naval (OPNAV) Group

OBJECTIVE: The object of this project is to explore, through research, the technical feasibility and then develop a modular suite of lightweight, rugged, field maintainable sensors capable of acquiring weather, pollution, geographic and seismic data that would be easily tailored for any a wide variety of missions. This modular suite would be used for the purpose of integration into Chemical/Biological detection systems and downwind hazard area prediction and modeling software/hardware applications. This new system would allow for intelligence operations to obtain pin-point source attribution and on-scene meteorological conditions, without having to rely on outdated ground force or satellite information.

DESCRIPTION: As part of the Intelligence Community of the 21st Century study it is reaffirmed some long held beliefs about the relatively unpredictable future – especially in terms of specific technologies the Community will face. One truism that seems to hold is that the sophistication of the technologies employed in the future weapons system (threats that the IC will be tasked against) will be radically improved, and perhaps even more radically different than those we attempt to understand today. The resulting need for a more sophisticated IC collection capability, with source attribution identification, is clear. However, as the sophistication of these targets increases, or as countries (Transnational/National players) employ effective denial and deception techniques, we will need to employ new capabilities to ensure we can continue to answer the consumer's questions.

The requirement for these efforts is a miniaturized low-power, modular environmental situational awareness system. More specifically, the effort requires a enclosed, portable, scaleable, real-time, stand-alone environmental analysis mass flow controlled system. This system must be able to push beyond the already available weather/pollution monitoring systems with development in state-of-the art micro-sensor [infrared, Time-of-flight [TOFr] Tetrahertz, Nano, Neutron-Based), technologies. The system should be able to collect total suspended particulate low to high volume [feasibility range 5 cfm – 150 cfm] of ambient air sampling, with wind speeds from 0 – 165mph, accuracy of less than 1% and minimum resolutions of 0.05m/s. Integration of ultraviolet sensor detectors in germicidal wavelengths to long-range ultraviolet rays of 280 nanometers (nm) [UV-B] to 400 nm [UV-A]. The system enclosure should be man-portable, preferably within the dimensions of 3' x 3' x 3' and be able to operate in a multi-operational temperature/condition range of 00 to 700 C. Maximum weight should not exceed 200 lbs and operate on 120VAC and consume no more than an average continuous power of 25 Watt. The system design should have applications for interchangeable weather and pollution monitors/sensors, computer controller, 1553 data bus, automated analysis process for source attribution analysis and automated report generation in unidentifiable output code format.

PHASE I: In Phase I, development of a breadboard design concept for a miniaturized, modular environmental situational awareness system. This integrated breadboard concept should be able to recognize sensory inputs of the following meteorological conditions; (1) identification of wind speed and direction, visible light, UV-A and UV-B and siphonable precipitation gauge and this project should recognize for at least two of the following environmental/pollution sensory inputs; (2) Nitrous Oxide, Sulfur Oxide, Carbon Dioxide and Ozone.

PHASE II: Improvement of system performance, from Phase I and analysis of system level alternatives should be performed. Build, test against the performance of the system design and deliver an advance concept technology demonstrator of the miniaturized modular environmental situational system.

PHASE III DUAL USE APPLICATONS: Prepare and develop full ownership identification, military and/or commercial opportunities for technology transfer into existing military or IC community users. Move program into full development and integration testing. Integration; test performance of the system against fleet existing Chemical/Biological systems utilizing a subset of agents, simulants and interferents, under multiple environmental conditions. Impact programs could be: Chemical and Bilogical Defense-Contamination Avoidance; Counterproliferation-Strategic and Tactical Intelligence, Battlefield Surveillance and Damage Assessment, Domestic Preparedness.

This system or systems has commercial targets that include but are not limited to: biotech/pharmaceutical research, chemical process monitoring, air/water environmental monitoring and testing, academia, and explosives analysis/development. It is conceivable that this technology could create new markets where previously capability, and/or analytic results prohibited consumers the luxury of existing tools.

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KEYWORDS: Weather, Pollution, Environmental, Sensor Integration, Weapons of Mass Destruction, Chemical/Biological Protection

AIR FORCE CBD SBIR TOPICS

CBD02-300 TITLE: Miniaturized Real-time Visible/UV Spectrometer

TECHNOLOGY AREAS: Chemical/Bio Defense

ACQUISITION PROGRAM: Joint Chemical and Biological Defense Program

OBJECTIVE: Develop a miniature spectrometer as a payload sensor for real-time spectral discrimination and identification of chemical agents from small delivery platforms.

DESCRIPTION: Future Air Force and DoD missions will depend on real-time detection and characterization of chemical agent clouds and vapors. Significant research is already underway for developing advanced miniature spectroscopic sensors for the purpose of chemical detection in the battlefield for passive defense. The objective of this research is to initially provide an enabling technology for a hand-held device for point detection and identification of harmful agents. Later efforts will integrate complete sensors incorporating this technology on small platforms for mapping and identification of chemical clouds in the battlefield environment. Both efforts seek to increase the maneuverability of the warfighter through exploitation of science and technology.

The requirement for these efforts is a miniaturized low-power visible/UV spectrometer. More specifically, the effort requires a single channel, enclosed, stand-alone, realtime, digitizing spectrometer with a sampling time of 100 ms and time of integration no greater than 20 ms and a signal-to-noise ratio less than 100:1. The dimensions of enclosure must be no larger than 3 in. x 3 in. x 1 in. (LWH) in any dimension. Maximum weight—not including power source—must be under 100 grams. The spectral region of operation needs to be between 200 nm – 800 nm with a maximum (worst-case) resolution of 1 nm. The device should operate on 5VDC and consume no more than an average continuous power of 1 Watt.

PHASE I: Develop a breadboard concept for the spectrometer as a step toward the miniaturized system. Design and develop a spectrometer prototype with estimated per-unit cost and performance ratings.

PHASE II: Improve system performance and revisit specification and analysis of alternatives on the system level. Build and deliver a finalized working prototype of the system, and test the performance of the system against a subset of agents, simulants, and interferents.

PHASE III DUAL USE APPLICATIONS: Chemical and Biological Defense-Contamination Avoidance; Counterproliferation-Strategic and Tactical Intelligence, Battlefield Surveillance, Battle Damage Assessment, Facility Characterization, Domestic Preparedness.

REFERENCES:
Ocean Optics Internet Web Site: http://www.oceanoptics.com/products/s2000.asp

KEYWORDS: Spectrometer, Miniature, Resolution, High, Bandwidth, Chemical, Agent

CBD02-301 TITLE: Exploitation of Quantum Well Interactions for Electro-optical Sensor Development

TECHNOLOGY AREAS: Chemical/Bio Defense

ACQUISITION PROGRAM: Joint Chemical and Biological Defense Program

OBJECTIVE: The goal is to characterize unique features from scattered light coupling to quantum well modes on random surfaces. Once modeled, the features may be used to improve the discriminating capabilities of surface enhanced Raman scattering (SERS) detectors, enhancing selectivity. Essentially, this effort seeks to bridge the gap between performance and support specifications for detect to warn and detect to treat systems.

DESCRIPTION: Chemicals that have similar molecular and bonding structures often have identical spectral features, making discrimination between these chemicals problematic for spectroscopic detectors. Surface enhanced Raman scattering spectroscopy has shown promise for sensitive detection of chemical agents within the joint services agent water monitoring program, but suffers from the same limitation on selectivity. Recent work with a novel composite material for the enhancement of SERS has shown that nanoparticles (10-50 nm diameter) induce quantum well interactions with the high surface fields. These interactions, likely due to coupling between electronic states of the metal nanoparticles and the large local field intensities, reveal an extremely rich spectrum of discrete spectral lines. In some specialized experiments this spectrum extends for over 600 nm from 200-800 nm under excitation by extremely weak pump powers of only a few milliwatts. It is known that the spectral characteristics of molecules adsorbed on the metal particles will exert a strong influence on the detailed structure of the broadband emission; however, we do not currently possess a model to explain the fine structure in terms of coupling between the adsorbed molecules and the metal particles. This is an especially important area of research in the continuing development of SERS technology, since it may offer a rich selection of spectral identifiers for similar chemicals that traditionally share major features. We envision progress in this area to be the result of both experimental and numerical efforts, drastically improving the performance of successful SERS techniques.

PHASE I: Setup nonlinear optical experiment to measure and isolate the fine structure from quantum well interactions from random surface media. Perform a variable analysis to determine the factors which influence the unique features. Build theoretical and computer models to reliably explain and predict the phenomenology, confirmed by experimentation.

PHASE II: Formalize model to use as a basis for SERS detector design and analysis. Construct a prototype system to exploit the unique features, and compare performance to conventional point detector systems. Compare performance to SERS detectors that do not discriminate based on the quantum well interactions. Quantify performance against simulants, interferents, and live agents.

PHASE III DUAL USE APPLICATIONS: Chemical and Biological Defense-Contamination Avoidance; Counterproliferation-Strategic and Tactical Intelligence, Battlefield Surveillance, Battle Damage Assessment, Facility Characterization, Domestic Preparedness; Medical-Contamination Diagnostic; Toxic Handling and Demilitarization-Detection and Monitoring.

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KEYWORDS: Surface, Enhanced, Raman, Scattering, SERS, Hyper-Raman, Composite, Random, Nanoparticle, Coupling, Quantum, Well, Interaction, Spectroscopy, Sensor, Detector

CBD02-302 TITLE: Reactive Functionality in Fabrics and Protective Coatings

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes, Human Systems

OBJECTIVE: To develop regenerable, robust materials that will actively protect personnel, equipment, and structures against contamination by chemical and/or biological (CB) agents during and after one or more attacks.

DESCRIPTION: The candidate technology will be a polymeric material or materials incorporating (but not limited to) two types of functionality:
1. A chemically reactive component or components that can be covalently coupled to an existing or growing polymer chain—for example, an isocyanate group could condense with hydroxyl groups on a cellulose molecule or on a growing polyurethane chain—and
2. A second (not necessarily separate) moiety that is able, with or without subsequent activating treatment after incorporation into the polymeric material, to neutralize the toxic liability of a wide selection of CB agents (demonstrated examples include chloramides and quaternary ammonium triiodides).
Preparation of monomeric molecules will be sufficient for phase I of this solicitation, but preference will be given to approaches that include demonstrating incorporation of the monomers into large molecules or—better—candidate materials, and evaluation of the properties of the products. Safety and projections of rate and efficiency of neutralization, cost to produce, simplicity to use and maintain, and durability in use and storage will be major factors in the selection process.

PHASE I: During phase I the contractor will identify or prepare candidate molecules containing both the coupling and the neutralizing components identified in the preceding paragraph. Contractor will conduct a critical experiment to demonstrate, in turn, coupling to a representative functional group and [after activation, if needed] neutralization of realistic surrogate chemical and biological agents by at least one of the candidate molecules.

PHASE II: During phase II, contractor will focus on development and evaluation of prototype reactive coatings and/or fabrics. Contractor may continue development of candidate monomeric molecules during phase II. Critical experiment[s] will examine material and chemical/antibiotic properties of coatings and/or fabrics prepared from candidate monomer[s]. Samples of candidate coatings and/or fabrics will be submitted as deliverable items for testing or other evaluation at the discretion of DoD components.

PHASE III DUAL USE APPLICATIONS: During phase III it is expected that contractor will pursue dual-use applications [for example, in infection control or personal hygiene products] to promote economy of scale, in addition to securing external funds to support completion of development of a shelf-ready product or products for DoD.

REFERENCES:
1. "Durable and Regenerable Microbiocidal Textiles," US Patent 5,882,357 (1999).
2. "Iodine/Resin Disinfectant: a Procedure for the Preparation Thereof," US Patent 6,045,820 (2000).
3. "Designing Surfaces That Kill Bacteria on Contact," Proc. Natl. Acad. Science, 98, 5981–5985 (2001).

KEYWORDS: Antibacterial, Chemical Agent, Biological Agent, Contamination, Neutralization, Decontamination

CBD02-303 TITLE: Improved Filters for Chemical Warfare Agent Detectors

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes

OBJECTIVE: Develop and demonstrate a novel, inexpensive, filter that will pass chemical agents with high vapor pressure but still protects the detector sensor from the natural environment.

DESCRIPTION: Innovative and creative solutions are needed to address filtration problems in the detection of chemical warfare agents. The next generation of chemical warfare agent detectors must sense chemical agents of interest and operate in worldwide climatic environments. These environments include atmospheres that contain a very high particulate count, such as, dusty roads, helicopter landing zones, and desert terrain. Additionally, the filter must protect the interior of the detector from liquid water. These environments are subject to chemical agent attack and the next generation of man-mounted detectors has to function in these various environments. The 10 common chemical agents of interest include the chemical warfare agent VX. VX has a high vapor pressure and is viscous in nature.

The Joint Chemical Agent Detector (JCAD) and Lightweight Chemical Agent Detector (LCAD) are the future man-mounted personal detectors under development by the United States and United Kingdom, respectively. Both detectors will require filters to survive in the harsh worldwide environments. New, inlet air filtration solutions are required to pass the agents of interest while excluding background particulate matter. The JCAD and LCAD are designed to require a minimum amount of operation and support activities. Any filter supplied for these detectors shall not increase their operating and support costs.

PHASE I: Using simulates, testing will be accomplished to prove the feasibility of the filtration method developed to effectively transport a VX nerve agent simulant across the media while excluding liquid water, sand, and dust as specified in MIL-STD-810. Specifically, the new method shall focus on the filtration media and any transport enhancements for Surface Acoustic Wave (SAW) and Ion Mobility Spectrometer (IMS) chemical agent detectors. Phase I will also address filter service life, cost per filter, and capability to scale-up the system proposed for mass production. In phase I, simulant data should demonstrate the feasibility of the improved filter.

PHASE II: Construct, assemble, and demonstrate a prototype filter. Demonstrate the capability to mass produce, or arrange for mass production of, the filters and integrate with the JCAD and LCAD detectors in a cost efficient manner. Government surety laboratory testing and additional simulant testing will be accomplished to verify the performance of the new filter when integrated with a detector and mass production processes.

PHASE III DUAL USE APPLICATIONS: Phase III military applications include fixed-wing aircraft, rotary-wing aircraft, tracked vehicles, wheeled vehicles, personnel, shipboard, and fixed-site applications. Phase III commercial applications include providing a novel filtration media to any air filtration device that must operation in adverse environments.

REFERENCES:
Web page -- http://www.sbccom.apgea.army.mil/products/jcad.htm

KEYWORDS: VX, Filter, Filtration, Chemical Warfare Agent Detector, Joint Chemical Agent Detector, Chemical Agent Detector, Surface Acoustic Wave, Ion Mobility Spectrometer

CBD02-304 TITLE: Enhanced Biorecognition Reagent System

TECHNOLOGY AREAS: Chemical/Bio Defense, Biomedical

OBJECTIVE: Recent progress in the development of artificial biorecognition molecules (or aptamers) has shown that these aptamers in many cases bind as tightly and may be more robust than the antibodies they replace. 1, 2 The object of this project is to develop a system for producing biorecognition molecules which can be replicated rapidly at a single temperature between ~18 C (or ambient) and ~37C, which bind uniquely to either a desired nucleic acid or a desired protein, and which can be stored without losing efficacy in a dried form for months at a time with all other necessary chemicals other than the replicating enzyme. The new system should enhance the technology of biorecognition molecules in a way that will impact overall identification system performance by at least an order of magnitude.

DESCRIPTION: The new system will provide methods and examples of nucleic acid aptamers which can unambiguously detect specified pathogens as well as specified protein toxins in ten minutes or less. Aptamers will be constructed which can be shown to identify specified proteins in numbers and concentrations better than has been shown to be achievable with antibodies presently available. The aptamers will be self-replicatable, without thermal cycling by a factor of the order of 10E13 only in the

presence of the target molecule and/or organism. The aptamers will be shown to survive in dirty environments and to be stable for several months in a ready-to-use state.

PHASE I: In Phase I, laboratory experiments with the developed reagent system must show that aptamers developed in this project recognize examples for at least two of the following, (1) a specific bacterial spore (2) a mammalian RNA virus, and (3) a specified protein, and indicate the presence of these entities at low levels and in conditions simulating field conditions. The aptamers must be shown to be propagated in the system under development by a factor adequate to be detected with a simple laboratory system in less than ten minutes without thermal cycling, at any single temperature in the range ~18 to 37 C. This requires use of an enzyme such as Qbeta replicase for RNA aptamers or development of an analogous enzyme with equal or better properties (robustness, fidelity, replication speed etc.) for replication of biorecognition molecules. The feasibility of the following must be shown. This replication must take place only in the case that the target molecule or organism is present. The target molecule must be identifiable with simple or no instrumentation, in concentrations lower than the best cases reported in refereed literature for antibody capture, or of the order of 200 target copies/ml.

PHASE II: The system must produce biorecognition molecules with a shelf life of at least several months in dried form and be reconstitutable simply by adding water. A kit will be fabricated using the technology developed in Phase I which consists of aptamers which can recognize several simulants and/or agents including two bacterial spores, two vegetative bacteria, a mammalian RNA virus, and two toxin simulants. The kit will contain these aptamers in dried form and also contain all chemicals necessary for the detection/identification process in dried form reconstitutable by adding water. The enzyme or enzymes necessary for the process will also be packaged in a storage form shown to survive conditions at least as severe as the storage form of any replication enzyme currently available for PCR identification systems. The kit must be usable with commercially available off the shelf instrumentation, no additional chemicals other than water, and must be supplied with a simple set of instructions for use and be usable with minimal additional instruction.

PHASE III DUAL USE APPLICATIONS: The aptamer systems produced will be utilizable in hospital pathology laboratories for very rapid identification of the presence of particular pathogens. They may be useful for monitoring food processing against the presence of common pathogens.

REFERENCES:
1. Klug, SJ and Famulok M., 1994, Mol. Biol. Rep. 20, 97-107.
2. S. S. Iqbal, M. W. Mayo, J. G. Bruno, B. V. Bronk, C. A. Batt, J. P. Chambers, "A review of molecular recognition technologies for detection of biological threat agents", Biosensors and Bioelectronics Vol 15, 549-578 (2000).
3. Brian Zeiler, Abraham Grossman, and Burt V. Bronk, Proceedings of SPIE Vol. 4036 Chemical and Biological Sensing, Chair: Patrick J. Gardner, (April 2000)

KEYWORDS: Aptamers, Biorecognition Molecule, Pathogen Identification, Toxin Identification

CBD02-305 TITLE: Residual Life Indicator for Advanced/Regenerable Air Filters

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes

OBJECTIVE: To develop a simple, robust technology that will accurately report the remaining capacity of adsorptive media in air filters in active service. For disposable media, this will permit disposal of individual units shortly before point of imminent failure, allowing maximum use of assets before disposal. For regenerable media, this technology will guide the schedule for reactivation.

DESCRIPTION: The candidate technology will create an observable or measurable response in proportion to the extent of saturation of the absorptive or adsorptive capacity along the sorption path of an existing or proposed static device for physical or chemical removal of CB agents and other volatile substances from air. A threshold response [for example, an oil-pressure indicator light] will qualify, but a graduated indicator [for example, differential pressure across a paint arrestor] would be preferred. Any property of the filter system may be used, and the process may include a challenge gas or other probe that neither significantly compromises the residual capacity of the filter nor dislodges contaminants previously adsorbed. A nonspecific detector is strongly preferred unless the specific material detected can be shown to accurately represent residual capacity to breakthrough of the least-strongly sorbed contaminant present. Cost, reliability, safety, and simplicity to use and maintain will be major factors in the selection process.

PHASE I: During phase I the contractor will conduct a critical experiment to demonstrate the technical feasibility of the physical/chemical principle to be used in the residual life indicator.

PHASE II: During phase II, contractor will assemble and evaluate the performance of an engineering model, which will be delivered to the government for possible further evaluation. The final evaluation will be conducted at >50 ft/min airflow and include a critical experimental test of the concept as implemented at that scale.

PHASE III DUAL USE APPLICATIONS: During phase III it is expected that contractor will pursue dual-use applications [for example, in odor or process air emission control, or personal safety equipment] to promote economy of scale, in addition to securing external funds to support completion of development of a shelf-ready product for DoD.

REFERENCES:
A example of an RLI specific for chlorine and mercury in the gas phase is discussed at http://www.osha-slc.gov/OshDoc/Interp_data/I19890301.html .

KEYWORDS: Air Filters, Adsorption, Absorption, Capacity, Breakthrough, Residual Lifetime

CBD02-306 TITLE: Establish a Non-aqueous Non-flammable and Non-corrosive Decontamination Process for Aircraft Cargo Interior

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes

OBJECTIVE: Develop a novel chem-bio decontamination process that can be used in aircraft cargo interiors without affecting the interior or its contents, and that can be applied in 15 minutes or less and not require reapplication.

DESCRIPTION: Innovative and creative solutions are needed to address the lack of a decontamination system that can decontaminate aircraft cargo interiors without affecting the aircraft, its equipment, the crew, or any cargo. Equipment and materials placed in cargo interiors span from delicate plastics to porous aluminum, all of which need to be decontaminated for continued worldwide use. This includes weapons, electronics and medical equipment. The host countries, where the aircraft may land, define the worldwide use of decontaminated materials differently. Therefore, all decontaminated materials from this process shall not off-gas chem-bio agents faster than a rate of 0.0018 mg-min-m3 (GD), 0.018 mg-min-m3 (HD) and 0.00061 mg-min-m3 (VX). Aircraft cargo interiors have numerous structural cavities that do not allow for standard aqueous-based decontamination processes. Also, the user community requires a decontamination system that can be applied in one single application and not require any additional support such as additional washing or vacuuming.

PHASE I: Phase I will produce a novel decontamination process to be used in aircraft cargo interiors. The proposed process will be tested to prove the efficacy and the results documented in the final report.

PHASE II: Phase II will develop a system prototype, fully tested, to demonstrate that the application can be accomplished in 30 minutes or less and that reapplication is unnecessary.

PHASE III DUAL USE APPLICATIONS: Phase III military applications include expansion of application to decontaminate sensitive equipment for the joint service community. Sensitive equipment involves equipment such as aircraft pitot tubes, optics, aircraft electronics ground equipment electro-mechanics and electronics, and composite materials. Commercial uses include decontamination of chemical spills during transport of hazardous materials via aircraft or commercial vehicles. More importantly, this solution can be used to decontaminate aircraft from other countries plagued with outbreaks of Foot and Mouth Disease or any other contagious disease where contamination of various types of surface materials is problematic.

REFERENCES:
"Large Aircraft Interior Decontamination Foreign Comparative Test Final Report December 2000", 311 HSW/YACN

KEYWORDS: Decontamination, Treatment, Toxic Industrial Material, Toxic Industrial Chemical, Chemical, Chemical Warfare Agent

SOCOM CBD SBIR TOPICS

CBD02-400 TITLE: Hand-held, Standoff Chemical-Biological Hazard Detector

TECHNOLOGY AREAS: Chemical/Bio Defense

OBJECTIVE: To develop a hand-held (flashlight sized) standoff detector capable of detecting chemical agent vapors and aerosols, chemical precursor vapors, and other potentially hazardous materials. An objective would be for detection of surface hazards (e.g. liquids). The system must identify the hazard by class (e.g. nerve agent, blood agent, choking agent, incapacitating agent, etc.), and be capable of distinguishing hazards in the presence of common interferents. An additional objective would be for the detector to provide specific identification of the hazard. The system should provide standoff detection from the detector out to a distance of ~150 feet, providing an audible or visual alarm. The detector should use standard batteries (objective). The power source should last a minimum of 12 hours, however, operations may not need to be continuous during this period.

DESCRIPTION: During direct action or room clearing operations in urban environments, special operations forces (SOF) must rely on point detectors and monitors for warning of CB-related hazards. These do not detect rapidly enough to provide sufficient warning for the individual carrying it to don protective gear. SOF operators are forced to either don protective gear prior to an operation, or risk potential exposure to hazards, which may incapacitate or kill. A hand-held standoff detector would allow SOF sufficient warning to don protective gear or avoid entry into hazardous areas.

PHASE I: Demonstrate viability of the recommended approach through bench-top prototype or existing proven technology. Develop an overall system design for a ruggedized hand-held, standoff detection system for identifying CB hazards.

PHASE II: Develop and demonstrate a ruggedized prototype hand-held, standoff detector in SOF mission scenarios. Verify hazard identification performance through simulated agent tests.

PHASE III DUAL USE APPLICATIONS: The technology could be adapted to a broad range of military and civilian hazard detection applications, such as a first responder detector for fire departments.

REFERENCES:
"A Critical Review of Sources of Spectral Data for Military Significant Compounds", CBIAC, Dec 1995, ISBN #1-888727-06-3

KEYWORDS: Chemical-Biological (CB) Detection, Standoff Detection, CB Agents, Precursors, Hazards

NAVY
PROPOSAL SUBMISSION
INTRODUCTION

The responsibility for the implementation, administration and management of the Navy SBIR program is with the Office of Naval Research (ONR). The Navy SBIR Program Manager is Mr. Vincent D. Schaper, (703) 696-8528. The Deputy SBIR Program Manager is Mr. John Williams, (703) 696-0342. If you have any questions of a specific nature, contact one of the above persons. For general inquiries or problems with the electronic submission, contact the DoD Help Desk at 1-866-216-4095 (8AM to 8PM EST). For technical questions about the topic, contact the Topic Authors listed under each topic on the website before **3 December 2001.**

The Navy's SBIR program is a mission-oriented program that integrates the needs and requirements of the Navy's Fleet through R&D topics that have dual-use potential. Information on the Navy SBIR Program can be found on the Navy SBIR website at **http://www.onr.navy.mil/sbir**. Additional information pertaining to the Department of the Navy's mission can be obtained by viewing the website at **http://www.navy.mil**.

PHASE I PROPOSAL SUBMISSION:

Read the DoD front section of this solicitation for detailed instructions on proposal format and program requirements. When you prepare your proposal, keep in mind that Phase I should address the feasibility of a solution to the topic. The Navy only accepts Phase I proposals with a base effort not exceeding $70,000 and with the option not exceeding $30,000. The technical period of performance for the Phase I should be 6 months and for the Phase I option should be 3 months. The Phase I option should address the transition into the Phase II effort. Phase I options are typically only funded after the decision to fund the Phase II has been made. Phase I proposals, including the option, have a 25-page limit (see section 3.3). The Navy will evaluate and select Phase I proposals using scientific review criteria based upon technical merit and other criteria as discussed in this solicitation document. Due to limited funding, the Navy reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded. The Navy typically provides a firm fixed price contract or awards a small purchase agreement as a Phase I award.

It is mandatory that the **entire** technical proposal, DoD Proposal Cover Sheet, Cost Proposal, and the Company Commercialization Report are submitted electronically through the DoD SBIR website at **http://www.dodsbir.net/submission**. If you have any questions or problems with the electronic submission contact the DoD SBIR Helpdesk at 1-866-216-4095 (8AM to 8PM EST).

NEW REQUIREMENT: ALL PROPOSAL SUBMISSIONS TO THE NAVY SBIR PROGRAM MUST BE SUBMITTED ELECTRONICALLY

Complete electronic submission includes the submission of the Cover Sheets, Cost Proposal, Company Commercialization Report, the **ENTIRE** technical proposal and any appendices via the DoD Submission site. The DoD proposal submission site **http://www.dodsbir.net/submission** will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these documents are submitted separately through the website. Your proposal must be submitted via the submission site on or before the **3:00 p.m. EST, 16 January 2002 deadline.** A hardcopy will NOT be required. A signature by hand or electronically is not required when you submit your proposal over the Internet.

Acceptable Formats for Online Submission: All technical proposal files will be converted to Portable Document Format (PDF) for evaluation purposes; therefore, submissions may be received in PDF format but other acceptable formats are MS Word, WordPerfect, Text, Rich Text Format (RTF), and Adobe Acrobat. The Technical Proposal should include all graphics and attachments, but not include Cover Sheets or Cost Proposal as they are submitted separately. Technical Proposals should conform to the limitations on margins and number of pages specified in the front section of this DoD Solicitation. However, your Cost Proposal will only count as one page and your Cover Sheets will only count as two, no matter how they print out after being converted. Most proposals will be printed out on black and white printers so make

sure all graphics are distinguishable in black and white. It is strongly encouraged that you perform a virus check on each submission to avoid complications or delays in downloading your Technical Proposal. To verify that your proposal has been received, click on the "Check Upload" icon to view your proposal. Typically, your proposal will be uploaded within the hour. However, if your proposal does not appear after an hour, please contact the DoD Help Desk. It is recommended that you submit early, as computer traffic gets heavy nearer the solicitation closing and slows down the system.

Within one week of the Solicitation closing, you will receive notification via e-mail that your proposal has been received and processed for evaluation by the Navy.

PHASE I ELECTRONIC FINAL REPORT:

All Phase I award winners must electronically submit a Phase I summary report through the Navy SBIR website at the end of their Phase I. The Phase I Summary Report is a non-proprietary summary of Phase I results. It should not exceed 700 words and should include potential applications and benefits. It should require minimal work from the contractor because most of this information is required in the final report. The summary of the final report will be submitted through the Navy SBIR/STTR website at: **http://www.onr.navy.mil/sbir**, click on "Submission", then click on "Submit a Phase I or II Summary Report".

ADDITIONAL NOTES:

1. The Small Business Administration (SBA) has made a determination that will permit the Naval Academy, the Navy Post Graduate School and the other military academies to participate as subcontractors in the SBIR/STTR program, since they are institutions of higher learning.

2. The Navy will allow firms to include with their proposals, success stories that have been submitted through the Navy SBIR website at **http://www.onr.navy.mil/sbir**. A Navy success story is any follow-on funding that a firm has received based on technology developed from a Navy SBIR or STTR Phase II award. The success stories should be included as appendices to the proposal. These pages will not be counted towards the 25-page limit. The success story information will be used as part of the evaluation of the third criteria, Commercial Potential (listed in Section 4.2 of this solicitation) which includes the Company's Commercialization Report and the strategy described to commercialize the technology discussed in the proposal. The Navy is very interested in companies that transition SBIR efforts directly into Navy and DoD programs and/or weapon systems. If a firm has never received a Navy SBIR Phase II it will not count against them. Phase III efforts should also be reported to the Navy SBIR program office noted above.

NAVY FAST TRACK DATES AND REQUIREMENTS:

The Fast Track application must be received by the Navy 150 days from the Phase I award start date. Your Phase II Proposal must be submitted within 180 days of the Phase I award start date. Any Fast Track applications or proposals not meeting these dates may be declined. All Fast Track applications and required information must be sent to the Navy SBIR Program Manager at the address listed above, to the designated Contracting Officer's Technical Monitor (the Technical Point of Contact (TPOC)) for the contract, and the appropriate Navy Activity SBIR Program Manager listed in Table 1 of this Introduction. The information required by the Navy, is the same as the information required under the DoD Fast Track described in the front part of this solicitation.

PHASE II PROPOSAL SUBMISSION:

Phase II is the demonstration of the technology that was found feasible in Phase I. Only those Phase I awardees which have been **invited** to submit a Phase II proposal by that Activity's proper point of contact, listed in Table 1, during or at the end of a successful Phase I effort will be eligible to participate for a Phase II award. If you have been invited to submit a Phase II proposal to the Navy, obtain a copy of the Phase II instructions from the Navy SBIR website or request the instructions from the Navy Activity POC listed in Table 1. The Navy will also offer a "Fast Track" into Phase II to those companies that successfully obtain third party cash partnership funds ("Fast Track" is described in Section 4.5 of

this solicitation). The Navy typically provides a cost plus fixed fee contract or an Other Transition Agreement (OTA) as a Phase II award. The type of award is at the discretion of the contracting officer.

Upon receiving an invitation, submission of a Phase II proposal should consist of three elements: 1) A base effort, which is the demonstration phase of the SBIR project; 2) A separate 2 to 5 page Transition/Marketing plan (formerly called a "commercialization plan") describing how, to whom and at what stage you will market and transition your technology to the government, government prime contractor, and/or private sector; and 3) At least one Phase II Option which would be a fully costed and well defined section describing a test and evaluation plan or further R&D. Phase II efforts are typically two (2) years and Phase II options are typically an additional six (6) months. **Each of the Navy Activities have different award amounts and schedules; you are required to get specific guidance from that Activity's SBIR Program Manager before submitting your Phase II proposal.** Phase II proposals together with the Phase II Option are limited to 40 pages (unless otherwise directed by the TPOC or contract officer). The Transition/Marketing plan must be a separate document that is submitted through the Navy SBIR website at **http://www.onr.navy.mil/sbir** under "Submission" and also included with the proposal submission online. All Phase II proposals must have a complete electronic submission. Complete electronic submission includes the submission of the Cover Sheets, Cost Proposal, Company Commercialization Report, the **ENTIRE** technical proposal and any appendices via the DoD Submission site. The DoD proposal submission site **http://www.dodsbir.net/submission** will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these documents are submitted separately through the website. Your proposal must be submitted via the submission site on or before the Navy Activity specified deadline. The Navy Activity that invited your PH II may also require a hardcopy or your proposal.

All Phase II award winners must attend a one-day Commercialization Assistance Program (CAP) meeting typically held in the July to August time frame in the Washington D.C. area during the second year of the Phase II effort. If you receive a Phase II award, you will be contacted with more information regarding this program or you can visit **http://www.navysbir.com/cap.**

As with the Phase I award, Phase II award winners must electronically submit a Phase II summary report through the Navy SBIR website at the end of their Phase II. The Phase II Summary Report is a non-proprietary summary of Phase II results. It should not exceed 700 words and should include potential applications and benefit. It should require minimal work from the contractor because most of this information is required in the final report.

The Navy has adopted a New Phase II Enhancement Plan to encourage transition of Navy SBIR funded technology to the Fleet. Since the Law (PL102-564) permits Phase III awards during Phase II work, the Navy will provide a 1 to 4 match of Phase II to Phase III funds that the company obtains from an acquisition program. Up to $250,000 in additional SBIR funds for $1,000,000 match of acquisition program funding, can be provided as long as the Phase III is awarded and funded during the Phase II. If you have questions, please contact the Navy Activity POC.

Effective in Fiscal Year 2000, a Navy Activity will not issue a Navy SBIR Phase II award to a company when the elapsed time between the completion of the Phase I award and the actual Phase II award date is eight (8) months or greater; unless the process and the award has been formally reviewed and approved by the Navy SBIR Program Office. Also, any SBIR Phase I contract that has been extended by a no cost extension beyond one (1) year will be ineligible for a Navy SBIR Phase II award using SBIR funds.

PHASE III

Public Law 106-554 provided for protection of SBIR data rights under SBIR Phase III awards. A Phase III SBIR award is any contract or grant where the technology is the same as, derived from, or evolved from a Phase I or a Phase II SBIR/STTR contract and awarded to the company which was awarded the Phase I/II SBIR. This covers any contract/grant issued as a follow-on Phase III SBIR award or any contract/grant award issued as a result of a competitive process where the awardee was an SBIR firm that developed the technology as a result of a Phase I or Phase II SBIR. The Navy **will** give SBIR Phase III status to any award that falls within the above-mentioned description. The governments prime contractors and/or their subcontractors will follow the same guidelines as above and ensure that companies operating on behalf of the Navy protect data rights of the SBIR company.

TABLE 1. NAVY ACTIVITY SBIR PROGRAM MANAGERS POINTS OF CONTACT (POC) FOR TOPICS

Topic Numbers	Point of Contact	Activity	Phone
N02-001 through N02-003	Mr. Rod Manzano	MARCOR	703-784-1395
N02-004 through N02-006	Mr. Milon Essoglou	NAVFAC	202-685-9172
N02-007 through N02-008	Ms. Susan Schneck	NAVSUP	717-605-1305
N02-009	Mr. Charles Marino	SSP	202-764-1553
N02-010 through N02-048	Mr. Mark Miller	NAVSEA	202-781-3746
N02-049 through N02-103	Mr. Douglas Harry	ONR	703-696-4286
N02-104 through N02-114	Ms. Linda Whittington	SPAWAR	858-537-0146

Do not contact the Program Managers for technical questions. For technical questions, please contact the topic authors during the pre-solicitation period from 1 October 2001 until 3 December 2001. These topic authors are listed on the Navy website under "Solicitation" or the DoD website. After 3 December, you must use the SITIS system listed in section 1.5c at the front of the solicitation or go to the DoD website for more information.

PHASE I PROPOSAL SUBMISSION CHECKLIST:

All of the following criteria <u>must be met</u> or your proposal will be REJECTED.

____1. **Your technical proposal has been uploaded. The DoD Proposal Cover Sheet, the DoD Company Commercialization Report, and the Cost Proposal have been submitted electronically through the DoD submission site by 3:00 p.m. EST 16 January 2002.**

____2. **The Phase I proposed cost for the base effort does not exceed $70,000. The Phase I Option proposed cost does not exceed $30,000. The costs for the base and option are clearly separate, and identified on the Proposal Cover Sheet, in the cost proposal, and in the work plan section of the proposal.**

NAVY 02.1 SBIR TITLE INDEX

N02-036	Engineering Control Human Performance Tool to Enhance Situational Awareness
N02-037	Low-Cost Automatic Shipboard Wireless Configuration Management
N02-038	Advanced Digital Array Radar (DAR) Sensor Systems/Subsystems
N02-039	Multiple Function Distributed Test and Analysis Tool
N02-040	Multi-Function Displays for Warfighter Consolidation
N02-041	Radar Technology/Unit Cost Reduction
N02-042	Low-Cost Wireless Shipboard Local Area Network
N02-043	Long Range Wireless Network Communication Capability
N02-044	Non-destructive Battery Inspection Techniques
N02-045	Thermal Management
N02-046	Ruggedization of Damage Control Equipment to Meet Shock Qualification Criterion
N02-047	Low Volume, Low Power, Real Time Image Processing
N02-048	Automated Battery Assembly

Office of Naval Research (ONR)

N02-049	Technology for Shipbuilding Affordability
N02-050	Predictive Durability Model for life Extension of Naval Waterfront Concrete
N02-051	Movable Platform for Deep Water, Wave Power Generation
N02-052	Computational Physics and Chemistry for Novel Materials
N02-053	Characterize and Optimize ATR Performance for EO/IR Sensors
N02-054	High Depth-of-Field Panoramic Video Acquisition and Analysis of Dynamic Scenes
N02-055	Parallel Patterning for Ultra-Submicron Magnetoelectronic Devices
N02-056	Packaging and Thermal Management for kW/cm2 Microwave Amplifiers
N02-057	All-Weather Landmark Identification, Correlation, Geolocation, and Inertial Measurement Unit
N02-058	High Energy, Long Pulse Laser
N02-059	Innovative Sensor Technologies for In-Situ Air-Sea Sampling Under High Wind Conditions
N02-060	Compact, High Density Energy Storage Devices
N02-061	Four dimensional (4-D) Atmospheric Instrumentation
N02-062	Ocean Data Telemetry Microsat Link
N02-063	Novel Methods for Real-time in situ Analysis of Lubricants, Coolants, Hydraulic Fluids, and Fuels for Condition Based Maintenance
N02-064	Advanced Energy Scavenging System for Condition-Based Maintenance
N02-065	Ultralight Periodic Cellular Metals for Marine Expeditionary Fighting Vehicles
N02-066	Naval Device Applications of Relaxor Piezoelectric Single Crystals
N02-067	Archival Knowledge for the Design, Manufacture and Visualization of a Set of Energetic Devices
N02-068	Miniature, Conformal, Waterproof Shear Stress Sensor Array
N02-069	Simplified analytical procedure for prediction of fracture damage in composite structures
N02-070	Methods for Monitoring Biodegradation of Pollutants in Estuarine Sediments
N02-071	Biology-Inspired Propulsion
N02-072	Legacy System Integrated Multimodal User Interface
N02-073	Mast-mounted In-Port Video Surveillance System
N02-074	Conversion of Supercritical Air Self-contained Breathing Apparatus (SCBA) for Diving Applications
N02-075	Advanced Ship Motion and Air Wake Sensing and Prediction
N02-076	Synthesis of Polyacetylene Curing Agents
N02-077	Elevation Data Generation using UAV Imagery
N02-078	Micro-Chip Laser Beam Switch for LADAR Transmitter Applications
N02-079	Flight/Hangar Deck Cleaner
N02-080	Vertical Flight Deck Operations Trainer
N02-081	Onboard HF Radar Ocean Current Mapping
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Space & Naval Warfare Systems Command (SPAWAR)

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FY 2002.1 Navy Topic Descriptions

MARINE CORPS SYSTEMS COMMAND (MARCOR)

N02-001 TITLE: Durability Improvement of Lightweight Track and Suspension Components for Armored Vehicles

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT ID: Advanced Amphibious Assault (AAAV)

OBJECTIVE: Improve durability and affordability of Lightweight AAAV track and suspension components.

DESCRIPTION: The Marine Corps AAAV is a 76,000 lb. armored vehicle designed to operate over harsh off-road terrain and in oceans and rivers. The AAAV uses lightweight track and suspension components to reduce the vehicle weight by thousands of pounds. Because the lightweight components are more susceptible to damage than heavier materials, the Marine Corps would like to enhance the component's durability without significantly increasing weight and cost. The current track and suspension components are subject to corrosion, impact, abrasion, and also to high tensile and compressive loads. These components are also expected to operate in severe environments such as high humidity, seawater, sand, mud, rocks, gravel, etc. Climatic conditions can range from –65°F to 125°F. The improved components must be capable of correctly interfacing with the existing track and suspension system design. This will ensure that the improved components can be assembled into the existing track and suspension system without requiring redesign of other components. Current track and suspension components, which would benefit from durability and weight reduction improvements include, but are not limited to, road wheels, sprocket carriers, support rollers, idler wheels, and track blocks.

PHASE I: Investigate advanced materials and processes to meet the above objective. The materials could include conventional and reinforced materials, and the components could be produced from advanced castings, forming techniques, and forging. Investigate processes that could include, but are not limited to, Friction Stir Processing, Super Plastic Forming, High Velocity Particle Compaction, laser forming and other processes that may permit producing components, combined with selective reinforcement of wear resistant materials for improved wear and durability. Evaluate and develop potential lower cost methods for producing components. Any production method that may result in any significant weight increase will not be considered. The objective is to produce components with greater durability but without any significant increase in cost or weight. A trade off analysis will be carried out to evaluate cost, weight, and durability of the component and the production method. Conduct material and corrosion laboratory testing to insure that the developed materials properties are suitable for the harsh environment described above. The materials and processes selected must comply with environmental regulations and requirements and must not include any hazardous materials. Document the results of the testing and analysis and make recommendations for materials and processes that warrant further investigation.

PHASE II: Conduct laboratory testing on test coupons to insure that the developed materials and processes meet the component design requirements. Down-select several track and suspension components for Phase II prototype development. Complete the preliminary design for each of the down-selected components. Design and fabricate a limited number of prototype components for testing. The prototype components produced will be used for field testing to be funded and carried out the AAAV Program Office. The objective of this testing is to verify and insure that the component meets all the design requirements and is suitable for insertion in production vehicles. The results from the field testing carried out by the government will be made available to the SBIR Program to help in producing a mature design suitable for full production. The trade off analysis will be updated to reflect the results of the Phase II testing. Prepare plans for fabricating components that successfully completed field-testing in quantities needed to support AAAV production and fielding requirements. Document the trade off analysis, test results, and the component fabrication plans in a technical report. Include conclusions and recommendations in the report.

PHASE III: Demonstrate producibility of the components and develop an implementation plan for the AAAV production. On the basis of the plan generated in Phase II, fabricate one vehicle set of each component selected and adequate spares for insertion in AAAV Production Vehicle. Develop a plan and demonstrate implementation of these components in other DoD and foreign governments Programs for armored vehicles and weapons systems.

COMMERCIAL POTENTIAL: Can be used where durable, lightweight materials are required. Commercial applications include automobile manufacturing, off-road vehicle equipment, and farm equipment.

REFERENCES:

1. Engineering Design Handbook, Automotive Series Automotive Suspensions, 14 April, 1967, published by United States Army Materiel Command, pg. 1-22
2. Fundamentals of Vehicle Dynamics, Gillespie, T. D., Copyright 1992, published by Society of Automotive Engineers, pg.147-189

KEYWORDS: Durability, Producibility, Affordability, Lightweight, Advanced Materials and Processes, Reinforcement, Hazardous Materials.

N02-002 TITLE: Remote Thermographer to Measure Skin Temperatures

TECHNOLOGY AREAS: Biomedical, Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: Joint Non-Lethal Weapons Directorate

OBJECTIVE: Use infrared thermography to remotely acquire accurate skin temperature measurements under various climactic conditions.

DESCRIPTION: Some battlefield and other emergence situations require that vital physiological parameters be measurable when direct contact is not possible. Remote infrared thermography of skin temperatures from individuals at distances greater than 200 meters is required. Solutions need to be found to compensate for the difficulties inherent in acquiring remote skin temperature measurements, such as variations in ambient conditions such as temperature, rain, fog, background noise, etc.

PHASE I: Create innovative approach to measure skin temperature with accuracy of +/- 1 C. Deliver a feasibility study to address temperature measurement accuracy, range, basic feasibility and cost. The feasibility study shall address means to compensate for variations in environmental conditions, including extreme ambient temperatures, humidity, fog, and rain.

PHASE II: Optimize the Phase I design, produce, evaluate, and deliver a full-scale prototype.

PHASE III: Full-scale development testing, and improvement of Phase II prototype.

COMMERCIAL POTENTIAL: Commercial applications of these technologies are possible in the area of civilian search and rescue activities, the monitoring of environmental conditions associated with such things as industrial air and water quality, and meteorological data gathering.

REFERENCES:

1. Choi, J. K., Miki, K., Sagawa, S., and Shiraki, K. Evaluation of mean skin temperature formulas by infrared thermography. Int J Biometeorol 1997 Nov 41:2 68-75
2. Ring, E. F., Quantitative thermal imaging. Clin Phys Physiol Meas 1990 11 Suppl A 87-95
3. Barnes, R. B. Determination of body temperature by infrared emission. J Appl Physiol 1967 Jun 22:6 1143-6
4. http://www.brooks.af.mil/AFRL/HED/hedr/hedr.home

KEYWORDS: Temperature Sensing, Thermography, Remote Thermal Sensor; Vital Signs Monitor

N02-003 TITLE: Non-Lethal Area Denial to Vehicles

TECHNOLOGY AREAS: Materials/Processes, Weapons

OBJECTIVE: To explore new non-lethal capabilities in the application of measured, selectable force for Area Denial to Vehicles that will reduce risks in both noncombatant and combatant casualties, friend or foe and damage to collateral equipment and structures.

DESCRIPTION: Stop a vehicle in urban/suburban terrain and/or rural open environment. This can be defined as the intentional denial of an area that has the characteristics of a city or countryside to hostile, friendly, or neutral vehicular traffic. City environments could include housing areas, single or multistory buildings, and streets from a single lane to six lanes with a median. Countryside terrain includes rolling or flat, soft or hard ground, forested, lightly forested or open. This denial includes, but is not limited to, denying vehicular access into an area by not allowing it to breach the area's perimeter.

PHASE I: Develop innovative system concept for denying an area to vehicles without significant collateral damage or casualties.

PHASE II: Optimize Phase I design and demonstrate technology solution against a realistic target.

PHASE III: Build prototype delivery system for technology solution(s) and demonstrate effectiveness of complete system. This demonstration should involve human test subjects, and as such the correct protocols need to be approved.

COMMERCIAL POTENTIAL: This system could be used by law enforcement agencies for riot, car chase and hostage situations.

REFERENCES:

1. Joint Non-Lethal Weapons Concept, Signed by LtGen M.R. Steele, Deputy Chief of Staff for Plans, Policy, and Operations, U.S. Marine Corps on 1/05/98, Available on World Wide Web at http://iis.marcorsyscom.usmc.mil/jnlwd/

KEYWORDS: Vehicles, Non-Lethal, Area Denial

NAVAL FACILITIES ENGEERING SERVICE (NAVFAC)

N02-004 TITLE: Dual Sander/High-Pressure Water Cleaning (HP WC) Unit for Recoat Surface Preparation

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IV NAVFAC Shore Facilities Advanced Development Project PE 603275N.

TECHNOLOGY AREAS: Materials and Processes: Civil Engineering

OBJECTIVE: Develop a robotic, closed-cycle, dual sander/High-Pressure Water Cleaning (HP WC) unit to clean/abrade sound coating systems applied to large exterior vertical surfaces.

DESCRIPTION: Neither the Government nor Industry has a robotic, closed-cycle, dual sander/High-Pressure Water Cleaning (HP WC) unit to clean/abrade sound coating systems, applied to exterior vertical surfaces of fuel and water tanks, in need of maintenance overcoating. Environmentally preferred water-based, high solids, low Volatile Organic Compound (VOC) maintenance coatings do not have the adhesion promoting qualities of their solvent-based counterparts and typically require linear scuff sanding of epoxies, urethanes, and alkyds in order to develop sound overcoat adhesion. Linear scuff sanding is labor intensive whereas brush-off blast cleaning (SSPC-SP 7) can micro-

fracture brittle coatings and generally requires containment to capture air borne dusts. Furthermore, High-Pressure Water Cleaning (HP WC) and High-Pressure Water Jetting (HP WJ) (SSPC-SP 12) effectively cleans sound coatings and removes unsound coatings but is unable to produce the desired scuff sanded surface (dull with visible scratches). The ideal robotic, vertical cleaning, closed-cycle, dual sander/High Pressure Water Cleaning (HP WC) unit could have the following design specifics: A) Pre-cleaning using Low Pressure Water Cleaning (LP WC) at » 4,000 psi, B) Roller sanding with grit impregnated bristles at » 250 rpm, C) Post-cleaning using High Pressure Water Cleaning (HP WC) at » 8,000 psi, D) ^{3} 2.5 foot cleaning path, E) Oscillating rotary head technology employed in water cleaning, and F) Resulting "cleaned" coated surface is free of biological growth, grime, chalk, and other contaminants, and appears dull with visible linear scratches equivalent to linear sanding with 120 grit to 220 grit sandpaper. Interested proposers should have previously demonstrated their in-house or joint venture capability for commercial marketing and production.

PHASE I: Develop a robotic, vertical cleaning, closed-cycle, dual sander/High-Pressure Water Cleaning (HP WC) unit.
PHASE II: Refine, test and field demonstrate the robotic, vertical cleaning, closed-cycle, dual sander/HP WC. The field demonstration should consist of vertical cleaning 2,000 SF of a sound but weathered high performance coating system such as that specified in Unified Facilities Guide Specification (UFGS)-09971N "Exterior Coating of Steel Structures." The resulting "cleaned" coating system should receive an overcoat of a water-based, elastomeric acrylic coating followed by adhesion testing (ASTM-D-4541, ASTM-D-3359). For the dual sander/HP WC unit, develop a draft Product Data Sheet (PDS) detailing equipment properties and cleaning capabilities, and produce a single draft brochure containing the above information.

PHASE III: Produce and market the robotic, vertical cleaning, closed-cycle, dual sander/HP WC unit demonstrated in the Phase II effort. Equipment manufacturer will include this product and the PDS (with brochure) in their current list and/or catalogue of commercial products and further commercialize the dual sander/HP WC unit by advertising in a reputable paint/coating trade journal. Surface preparation for maintenance painting using the dual sander/HP WC unit will be specified by Naval activities through amendments to UFGS-09971N and by developing new UFGSs detailing maintenance painting: specification development ensures procurement of dual sander/HP WC unit by tri-service contractor base. Intended users are Navy, Army, Air Force, Marines, Bureau of Reclamation, and private industry.

COMMERCIAL POTENTIAL: Surface preparation technology is directly transferable for use in preparing sound but weathered coating systems applied to ship hulls, bridges, fuel tanks, water tanks, structural steel, and concrete structures.

REFERENCES:

1. Society for Protective Coatings (SSPC), "Surface Preparation and Cleaning of Steel and Other Hard Materials by High- and Ultrahigh-Pressure Water Jetting Prior to Recoating," SSPC-SP 12, 1996.
2. William M. Thomas, "Closed-Cycle, Ultra-High Pressure Water Coatings Removal System: Prototype-to-Production Final Report," NSWC, March 1999.
3. C. Dave Gaughen and Joseph H. Brandon, "Preliminary Investigation into the Exterior Use of Elastomeric Acrylic Coatings for Naval Facilities," NFESC, March 2000.
4. C. Dave Gaughen and Joseph H. Brandon, "Guidance Development: Elastomeric Acrylic Coating (EAC) for Naval Facilities," NFESC, August 2000.

KEYWORDS: Sander, Surface Preparation, Water, Water Jetting, High Pressure Water Cleaning, Paint, Coating, Closed-Cycle.

N02-005 TITLE: <u>Pre-Packaged Non-Skid Media for Aviation Facility Flooring</u>

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IV: NAVFAC Shore Facilities

OBJECTIVE: Develop pint and half-pint quantities of white, premixed, packaged, nonskid media for use with the two component urethane topcoat specified in both UFGS-09611N "Thin Film Flooring" and UFGS-09612N "Epoxy Mortar Flooring."

DESCRIPTION: Neither the Government nor Industry has pint and half-pint quantities of premixed, packaged, nonskid media for direct mixing into a liquid applied industrial flooring topcoat. Commercially available nonskid media (#60 aluminum oxide) is traditionally broadcast directly into a wet topcoat at 1.0 pound per 100 SF and backrolled. This technique is labor intensive (10 hours to broadcast/coat per 37,000 SF whereas 4 hours to coat w/out broadcasting per 37,000 SF), results in uneven nonskid densities, and prevents the use of potentially higher performing smaller nonskid media (particles > #70 drift in air). Pint and half-pint quantities of premixed, packaged, smaller nonskid media for direct mixing into liquid urethane topcoats will eliminate errors in contractor nonskid broadcasting, increase contractor rate of nonskid application, improve nonskid performance, decrease the frequency of rejuvenating maintenance overcoating, and reduce total ownership costs. An ideal flooring media would have these design characteristics: A) Shape; angular spheres, B) Mohs hardness; 7.0 – 9.0, C) Density (dry, solvent immersed); 9.0 lbs/gallon to 20 lbs/gallon, D) Size gradation (ASTM-E-11); Sieve No. 70 100% passing, Sieve No. 80 15% - 30% retained, Sieve No. 100 70% - 80% retained, Sieve No. 120 0% - 15% retained, E) Suspension vehicle; urethane compatible solvents, F) Volatile Organic Compounds (VOC); < 400 grams/liter, G) Hazardous Air Pollutants (HAPs); 0%, H) Media surface treatment; adhesion promoters and/or coupling agents, if required, I) Chemical resistance; skydrols, aircraft oils, and JP fuels, J) 1 pint nonskid mixed with 1 gallon pigmented urethane topcoat meeting UFGS-09611N; No settling, coagulation, floating, discoloration, incompatibility, foaming, solvent popping, and separation, with viscosity less than 1200 cps (ASTM-D-2196: 20°C). Approximate cured performance requirements using the mix ratio listed in "J" at 3.0 mils dry film thickness: 1) No mottling, 2) Adhesion to urethane (ASTM-D-4541); > 600 psi, 3) Percent elongation (ASTM-D-2370); > 10 %, 4) Coefficient of Friction (ASTM-D-2047); > 0.68, and 5) Abrasion resistance (ASTM-D-4060); < 30 mg loss @ 1000 revolutions. Interested proposers will have demonstrated by either in-house or joint venture efforts an ability to commercially market products.

PHASE I: Develop a "white" prepackaged nonskid media for aviation facility flooring purposes.

PHASE II: Refine, test and field demonstrate the prepackaged nonskid media developed under the Phase I effort. As a minimum, the field demonstration should consist of applying three out of the five pre-approved coating systems listed in UFGS-09611N direct to 10 foot by 10 foot areas of concrete. Prior to application, each 100 SF area will employ up to 1 pint of the prepackaged nonskid media mixed into the second topcoat of urethane. For the prepackaged nonskid media draft a Product Data Sheet (PDS) detailing material properties and application characteristics

PHASE III: Produce and market the prepackaged nonskid media demonstrated in the Phase II effort. Nonskid manufacturer will include this product and an improved PDS in their current list and/or catalogue of commercial products and further commercialize the prepackaged nonskid media by advertising in a reputable paint/coating trade journal. The prepackaged nonskid media will be procured by Naval activities through amendments to UFGS-09611N and UFGS-09612N. Intended users are Navy, Army, Air Force, Marines, Bureau of Reclamation, and private industry.

COMMERCIAL POTENTIAL: The pre-packaged non-skid media for urethane topcoats will be used primarily in industrial flooring and potentially in slip resistant topcoats applied to combat vehicles (MIL-C-53039), ground support (MIL-C-46168), aircraft (MIL-PRF-85285), bridge decks, architectural structures, etc. Industrial flooring with slip resistance is generally applied to the floors of refineries, petrochemical plants, food and beverage facilities, water and wastewater plants, pulp and paper mills, nuclear facilities, power plants, process factories, automotive production facilities, equipment maintenance shops, and others.

REFERENCES:

1. C. Dave Gaughen, "Guidance Development: Thin Film and Epoxy Mortar Flooring Systems," NFESC, August 2000.
2. Unified Facilities Guide Specification (UFGS)-09611N "Thin Film Flooring System for Aircraft Maintenance Facilities," NAVFAC, March 2001.
3. UFGS-09612N, "Epoxy Mortar Flooring System for Aircraft Maintenance Facilities," NAVFAC, March 2001.
4. C. Dave Gaughen, "Floor Coatings for Aviation Facilities," ACI International, Philadelphia PA, March 25 – 30 2001.
5. E-11, "Standard Specification for Wire-Cloth Sieves for Testing Purposes," ASTM, 1987.
6. MIL-PRF-85285, "Coating: Polyurethane, High Solids," April 1997.

7. MIL-C-46168, "Coating, Aliphatic Polyurethane, Chemical Agent Resistant," May 1993.
8. MIL-C-53039, "Coating, Aliphatic Polyurethane, Single Component, Chemical Agent Resistant," November 1988.

KEYWORDS: Nonskid, Slip Resistance, Coating, Paint, Urethane, Thin Film, Epoxy Mortar.

N02-006 TITLE: Polysulfide Modified Epoxy Novolac Cladding for Steel Immersion/Splash Zone Service

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IV: NAVFAC Shore Facilities

OBJECTIVE: Develop spray applied, self-priming, fast cure, flexible, edge retentive, impact and abrasion resistant, polysulfide modified epoxy novolac cladding for corrosion control of steel in salt water immersion/splash zones.

DESCRIPTION: Unified Facilities Guide Specification (UFGS)-09967N "Coating of Steel Waterfront Structures" employs two coating system options for use in the initial painting of steel placed in sea water immersion/splash zones: 1) three coats epoxy-polyamide (SSPC PS 13.01: SSPC Paint 22), 2) two coats coal tar epoxy-polyamide (SSPC-PS 11.01: SSPC Paint 16). Each system displays approximately five years splash zone service before complete removal and reapplication is required. Commercially available, in-service applied splash zone maintenance coatings generally provide three additional years service prior to reapplication. As such, the development of a polysulfide modified epoxy novolac cladding for use in initial/maintenance painting of immersed/splash zone steel will improve corrosion control, decrease the frequency of maintenance painting, and reduce total ownership costs. Experience indicates that a cladding system should meet the following approximate requirements: A) Application; spray, B) Application thickness; sag free @ 5 mm (200 mils), C) Crack free thickness; > 25 mm (1 inch), D) Cure; wash-out resistant @ 20 minutes, E) Adhesion to Ultrahigh-Pressure Water Jetted (HP WJ) steel (ASTM-D-4541); > 600 psi (cohesive failure), F) Percent elongation; 20% to 80%, G) Abrasion resistance (ASTM-D-4060); < 30 mg loss @ 1000 revolutions, H) Simulated sea water immersion; < 0.5% weight gain @ 168 hours, I) Cathodic disbondment(NACE RPO394-94: 24-hour test); < 1 mm disbonded radius, J) Compressive strength; > 10,000 psi, K) Edge retentive; > 65% flat surface film thickness retained on edges, L) Volume solids; 100%, and M) Environmentally compliant; HAPs and toxic metal free. Interested proposers should have previously demonstrated their capability for commercialization and production either by in-house or joint venture partnering.

PHASE I: Develop a polysulfide modified epoxy novolac cladding for steel immersion/splash zone service.

PHASE II: Refine, test and field demonstrate the polysulfide modified epoxy novolac cladding. Demonstrate by standard Industry practice that the cladding meets the acceptable coating performance criteria for rust undercutting, edge retention, thermal cycling resistance, wormhole wettability, wet adhesion, impact strength, and abrasion resistance as defined in Reference 1. For the cladding, draft a new Product Data Sheet (PDS) detailing material properties and application procedures.

PHASE III: Produce and market the cladding demonstrated in the Phase II effort. Cladding manufacturer will include this product and an improved PDS in their current list and/or catalogue of commercial products and further commercialize the cladding by advertising in a reputable paint/coating trade journal. The cladding will be procured by Naval activities through amendments to UFGS-09967N. Intended users are Navy, Army, Air Force, Marines, Bureau of Reclamation, and private industry.

COMMERCIAL POTENTIAL: The polysulfide modified epoxy novolac cladding will be for use on bulkheads (sheet pile), pipe piles, H-piles, cranes, in-shore/offshore petrochemical structures, ships (ballast tanks), bridges, water and wastewater structures, industrial facilities, mooring structures, and marine equipment.

REFERENCES:
1. Benjamin Chang and Carl Guy, "Evaluating Maintenance Coatings for Offshore Platforms in the Gulf of Mexico," JPCL, Vol. 17, No. 2, February 2000.

2. Society for Protective Coatings (SSPC), "Surface Preparation and Cleaning of Steel and Other Hard Materials by High- and Ultrahigh-Pressure Water Jetting Prior to Recoating," SSPC-SP 12, 1996.

KEYWORDS: Coating, Paint, Cladding, Immersion, Splash Zone, Marine.

NAVAL SUPPLY SYSTEMS COMMAND (NAVSUP)

N02-007 TITLE: Obsolescence Management Solutions

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: NAVSUP 04, Navy Logistics Productivity Program

OBJECTIVE: To resolve obsolescence problems, the government spends millions of dollars to emulate replacement parts, redesign systems and equipment, find alternative sources or invest in life of type buys. To avoid or reduce inflating life cycle costs resulting from naval weapon system/equipment obsolescence, the Navy Logistics Productivity Program is looking for new preventive measures, detection techniques and technology-based solutions to manage the effects of obsolescence and declining parts availability.

DESCRIPTION: When the last known manufacturer announces the intention to discontinue production of an item or group of items still required by the Department of Defense for weapon system support, the weapon system's readiness and/or sustainability can be dramatically impacted. A component is determined to be obsolete when its commercial availability becomes limited or nonexistent. Because of rapid changes in technology, functional and economic obsolescence are significant contributors to the high life cycle costs of Navy weapon systems. The goal of this topic is to identify, develop and demonstrate the replacement or upgrade of a Navy system, subsystem or equipment suffering from obsolescence through new obsolescence preventive measures, detection techniques or technology-insertion solutions. Two existing technology insertion (i.e., the transition of an existing hardware's form, fit and function into new technology replacement hardware) examples are NAVSUP's Compatible Processor Upgrade Program (CPUP) and Rapid Retargeting (RRT) Program. The proposed system, subsystem or equipment may be electronic, mechanical or electro-mechanical. Tools associated with obsolescence prevention, detection or technology insertion will also be considered. The technology demonstration must also provide a clear cost avoidance over the current system or equipment's replacement/upgrade strategies and significantly contribute to total ownership cost reduction.

PHASE I: Develop an overall obsolescence tool/technique/system design, including cost/benefit factors and a technical specification demonstrating feasibility.

PHASE II: Develop and demonstrate a prototype in a realistic environment. Conduct testing to demonstrate feasibility over extended operating conditions.

PHASE III: Develop and deliver a final application of the technology for commercial and military use.

COMMERCIAL POTENTIAL: The methodology, tool or new product could be used in a broad range of military and civilian applications where spare and repair parts obsolescence is a significant detractor.

REFERENCES:
1. Navy Logistics Research & Development Program, Gary Fitzhugh, Richard Comfort and James Fitzgibbon, available at http://www.nlc2000.org/papers/Fitzhugh.pdf
2. Government Initiatives to Solve Diminishing Manufacturing Sources/Material Shortages (DMSMS), available at http://www.gidep.corona.navy.mil/dmsms/dmsinfo.htm
3. Virtual Systems Implementation Program (VSIP), James Fitzgibbon, available at http://www.navsup.navy.mil (Logistics Research and Development Programs)
4. Compatible Processor Upgrade Program (CPUP), James Fitzgibbon, available at http://www.navsup.navy.mil (Logistics Research and Development Programs)

5. Rapid Retargeting (RRT) Program, James Fitzgibbon, available at http://www.navsup.navy.mil (Logistics Research and Development Programs)

KEYWORDS: Obsolescence, Technology Insertion, Electronics, Mechanical, Electro-Mechanical, Tools

N02-008 TITLE: Three-Dimensional (3-D) Anthropometrie Data; Apparel Application Methods and Tools

TECHNOLOGY AREAS: Materials/Processes, Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IV: NCTRF-Navy Clothing and Textile Research

OBJECTIVE: To develop tools for incorporating 3-D anthropometry (human body measurements) data into design, sizing and manufacturing processes for body forms, military and civilian apparel, and protective items for DOD and the apparel industry.

DESCRIPTION: Scanners now exist for capturing the human body in 3-D. 3-D data are being gathered from Army, Air Force and Marine Corps personnel. A survey of the adult civilian population of NATO countries is also underway. Some industries, such as the automotive industry, have ergonomic models and have already begun to incorporate 3-D anthropometry. There is both a need and an opportunity to develop new and better tools for incorporating 3-D body size in design and manufacturing processes for the apparel industry. At the present time, 3-D information is not being routinely used in the apparel industry because of the lack of tools that are compatible with apparel industry practices, needs, and capabilities. Some examples of things needed include:

- Accurate 3-D electronic human apparel size models composed of the 3-D surface data of real people, and incorporated into 3-D Computer Aided Design (CAD) systems for apparel,

- Accurate physical dress forms that reflect the 3-D size and shapes of real people, and fast and reliable methods for production of such forms,

- Electronic 3-D size and shape models of people that are representative of the anthropometric variation found in military and civilian (male, female, children, big, small, pregnant) population, for visualizing standard sizes and size differences,

- 3-D size and shape comparison and editing tools for apparel, and

- Manufacturing methods for production of apparel in 3-D.

The purpose of this effort is to develop a tool to satisfy one or more of these needs.

PHASE I: Develop system concept and assess feasibility of design.

PHASE II: Develop a tool prototype and conduct beta testing with government and industry users.

PHASE III: Complete, test and deliver final tool.

COMMERCIAL POTENTIAL: These methods and tools could be applied for developing sizing systems and patterns and for manufacturing body forms, garments, masks, gloves, or boots for civilian and military population.

REFERENCES:

1. Brunsman, M.A., Daanen, H., and Files P.S. (1996). Earthquake in Anthropometry: The View from the Epicenter. CSERIAC Gateway, Vol. VII, No. 2. Brunsman, M.A., Daanen, H., and Robinette, K.M. (1997). Optimal Postures and Positioning for Human Body Scanning. Proceeding of International Conference on Recent Advances in 3-D Digital Imaging and Modeling, pp. 266-273. IEEE Computer Society Press, Los Alamitos, CA.

2. Brunsman, M.A. and Files. P.S. (1996), The CG Dataset: Whole Body Surface Scans of 53 Subjects (U), AL/CF-TR-1996-0160, Crew Systems Directorate, Human Engineering Division, Wright-Patterson Air Force Base, OH.
3. Burnsides, Dennis B., Files, Patrick, and Whitestone, Jennifer J. (1996), Integrate 1.25: A Prototype for Evaluating Three-Dimensional Visualization, Analysis and Manipulation Functionality (U), AL/CF-TR-1996-0095.
4. Daanen, H., Brunsman, M.A (1998) Difference between manual anthropometric measurements and anthropometric measures derived manually from whole body scans: a pilot study. TNO-report TM-98-A004, TNO Human Factors Research Institute, Soesterberg, The Netherlands.
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KEYWORDS: Apparel, Patterns, Body Forms, Sizing, Anthropometry, Automation.

STRATEGIC SYSTEMS PROGRAMS OFFICE (SSPO)

N02-009 TITLE: Tunable, Reconfigurable Weapon Shock and Vibration Mitigation System

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop and demonstrate a tunable, reconfigurable, shock and vibration mitigation system to support submarine based weapon systems developers and to assist life extension of existing FBM launch systems.

DESCRIPTION: The current generation of SSBN's is expected to extend for the next several decades. During this time, it will be necessary to upgrade the FBM weapon system to extend the capability of the existing platform. Pads are utilized in FBM launcher systems to cushion the missile during shock events. The design and location of these pads is a function of the missile geometry, weight distribution and load capabilities. The deployment of a new or upgraded missile could require a change in these parameters. The current shock pads would have to be replaced with pads containing different stiffness properties. This would create difficulties when more than one missile configuration is required since it would preclude interchangeability on the same launcher platform. New, developing technologies in the area of intelligent materials might be used to solve this problem, like Magneto-rheological fluids (MRF).

PHASE I: Develop a system design for a Trident submarine based vertical launch weapon system. Identify trade-offs between current pad technology and proposed new technologies using creative and innovative approaches to solving this problem.

PHASE II: Test the previously designed system and demonstrate shock and vibration mitigation capabilities in a spectrum of system inputs.

PHASE III: Prepare modeling systems to specify systems variables for designing DoD and commercial applications.

COMMERCIAL POTENTIAL: This system has significant applicability to: commercial systems for active control of bicycle, motorcycle, passenger vehicle suspension systems, large freight-carrying trucks and rail cars as well as landing

gear systems on aircraft and for damping of earthquake shock inputs to highway bridges.

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KEYWORDS: Magneto-Rheological, Shock, Vibration, Materials, Dampers, Processes

NAVAL SEA SYSTEMS COMMAND (NAVSEA)

N02-010 TITLE: High Energy Free Electron Laser (FEL) for Ship Self-Defense

TECHNOLOGY AREAS: Sensors, Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT III: PMS 452; PEO TSC – Navy Theater Wide Ballistic Missile Defense

OBJECTIVE: Design, develop, and demonstrate components in support of a Free Electron Laser System that can be packaged for naval platforms.

DESCRIPTION: Chemical lasers produce power levels in excess of a megawatt, however the wavelengths that they operate at are not suitable for maritime propagation. FEL's provide for tunability (wavelength selection) to adapt and optimize lethality effects in the maritime environment. While the current state of the art for free electron lasers produce insufficient power to be considered a naval weapon, Thomas Jefferson Laboratory has recently achieved an average power of 1.72 kW, and their design shows promise toward scaling to 100's of kilowatts and possibly the megawatt level. Their progress has been achieved by combining cutting edge technologies, which include super conducting Radio Frequency (RF) cavities and electron beam energy recovery. Free Electron Lasers have considerable advantages over other laser sources for the maritime environment. In addition to wavelength tunability, these advantages also include potential for scaling to high powers, and pulsed waveforms that may offer lethality advantages over CW lasers.

The DoD High energy Laser Master Plan (HELRP) recommends that the DoD stimulate the High-Energy Laser supplier base with a few focused investments. Specifically, under Free Electron Lasers, the top three priority investments are; 1) High Average Current injectors, 2) High Power Optical Resonators/Undulators, and 3) High Average Current Electron Beam transport. Specific laser requirements (as reported in the DoD HELRP) for this effort include efforts leading to:

-Development of ampere level average current injectors with good electron beam quality.

-Development of high power super-conducting RF accelerator components (windows, absorbers, tuners).

-Development of optical resonators and high flux optics and coatings.

-Development of techniques to focus and bend, without spill, high current beams with energy spread.

-Demonstration of higher efficiency wiggler extraction without energy recovery or with straight line energy recovery.

-Development of passive and active alignment and control systems to counter system flexing, vibration, and induced microphonics in a non-laboratory environment.

-Development of higher-gradient (>12 MV/m) RF linear accelerators capable of handling multi-nanocoulomb electron bunches and amp level average currents.

-Integration and demonstration of subsystems at the ampere level.

PHASE I: Investigate enabling component technologies and designs that are capable of enabling specific laser requirements listed above. Demonstrate component design feasibility via modeling and simple sub-scale or oversized experiments.

PHASE II: Utilize the findings established in Phase I to develop designs of functional components. Fabricate and conduct component demonstration. Conduct High Power FEL integration requirements study to develop specific component design characteristics.

PHASE III: Implement the integration of the enabling technologies into a Free Electron Laser weapon demonstration test site to be determined in the future

COMMERCIAL APPLICATIONS: Many applications in materials processing require the use of high power laser beams for surface treatments. Development of a multi-megawatt laser source, with variable wavelength tunability will allow large scale treatment of various materials by industry users. The treatments aid in the prevention of surface erosions, cracks, and other effects common to large surface area industrial materials.

REFERENCES:

1. DoD Laser Master Plan Volume II, August 2, 2000. ODUSD (S&T)/WS LMP Vol-II, 22 September 2000

KEYWORDS: Laser, Free Electron, Wiggler, Resonator, Accelerator, Injectors, Superconducting, Windows, Beam Transport

N02-011 TITLE: Battle Force Reliability Modeling and Simulation

TECHNOLOGY AREAS: Information Systems, Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: PMS 470 – PEO (EXW) Expeditionary Warfare Life Cycle Support

OBJECTIVE: To extend the NAVSEA TIGER Reliability, Maintainability, and Availability (RMA) computer simulation from its present total ship modeling capabilities to entire Battle Force assessments.

DESCRIPTION: RMA modeling and simulation has been validated and accepted by the Navy and shipbuilding communities to predict the performance of future concepts and perform tradeoffs of various functions and equipment to minimize onboard maintenance workload and total ownership costs. Mission profiles are employed to determine the response to varying levels of stress on the systems during actual operations. Predictions have been carried out for line replaceable units through total ships with hundreds of pieces of equipment and the software required for successful operation. This innovation research is focused on extending this computer program to modeling the massive task of Battle Force simulation and tradeoffs.

PHASE I: Assess the magnitude of enhancements required to model full Battle Force operations, ship to ship interactions, and redundancies with respect to Battle Force mission profiles.

PHASE II: Incorporate enhancements, algorithm changes, input and output modifications, and graphical capabilities in the computer simulation. Integrate all capabilities, benchmark and validate the computer code with respect to very complex government and commercial problems.

PHASE III: Develop user friendly on-line users manuals and provide transition of the program to commercial industry.

COMMERCIAL POTENTIAL: Current commercial RMA computer programs do not model massively complex projects the size of Battle Force operations and their missions. The integrated capabilities of the NAVSEA TIGER RMA simulation can be transitioned to the most complex commercial systems and detailed operations.

REFERENCES:

1. NAVSEA TE660-AA-MMD-010, "TIGER Users Manual (Version 9.6)"; SAE JA 1000-1 "Reliability Program Standard Implementation Guide"; International Electrotechnical Commission (IEC) 60300-3-1 Ed. 2 "Dependability management - Part 3-1: Application Guide - Analysis Techniques for Dependability - Guide on Methodology".

KEYWORDS: Reliability and Maintainability (R&M), Modeling and Simulation, TIGER, Battle Force, Mission Profiles

N02-012 TITLE: <u>Video Analysis System for Machinery Condition Assessment</u>

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IV: PEO Carriers

OBJECTIVE: Develop and demonstrate an advanced digital video system to conduct ship ship's condition assessment and personnel assessments in a harsh industrialized shipboard environment. The video system must be able to visually detect structural changes in ship's structure, such as material fatigue, monitor operating machinery conditions, such as machinery operating temperatures and provide personnel identification and tracking capabilities, such as bio-metric data in low light situations. The system will develop data processing tools to process this information into an easily understood format that can be transported easily to other databases.

DESCRIPTION: Video technology has been demonstrated as a useful tool for recording, storing, and analyzing event triggered phenomena. Unfortunately, the recorded phenomenon has been restricted to two-dimensional observation and analysis, due to physical limitations of the media. Currently low levels ambient light many times is the limiting factor, in processing video imagery. This effort would use emerging technology in light processing research and pattern recognition research to build a system for capturing, manipulating, and analyzing restructured spatial data from recorded and real-time image captured information. This potential system should have an easily understood Human Machine Interface (HMI) and utilize common database processing elements to combine video data, measured data and history data to assess machinery reliability and machinery functionality. It should also utilize an automated analysis process, and automated report generation.

PHASE I: Develop a system concept for a Video Analysis System in sufficient detail to convey the physical and performance characteristics of the potential video systems. Evaluate and analyze new digital video collecting technologies. Provide Video Analysis System Metrics (i.e. environmental profile characteristics) that will be used to evaluate performance of the prototype in Phase II. Also provide Technology Limitations Report that describes the physical profiles required for the System Concept Design parameters.

PHASE II: Develop a prototype system that would be able to demonstrate the ability of the Video Analysis System to assess the material integrity of a shipboard space, provide real-time temperature profiles of machinery systems in a space and demonstrate personnel bio-metric information of personnel in a machinery space.

PHASE III: Develop video analysis system specification and begin production of a video analysis system.

COMMERCIAL POTENTIAL: This system could be applied in any factory or environmentally harsh area, where it would be physically unacceptable or dangerous for direct human interaction.

KEYWORDS: Automation, Analysis, Video, Task, Reduction, Workload

N02-013 TITLE: Development of Bulkhead and Overhead Coverings Suitable for Naval Marine Applications

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT ID: PEO Carriers; PMS 378 – CVN(x) Next Generation Nuclear Aircraft Carrier

OBJECTIVE: Identify and develop a lightweight, durable, sound attenuating, flame resistant, non-toxic, economical commercial style coverings suitable for application to bulkheads and overheads in the Naval marine environment.

DESCRIPTION: Current coverings identified for Naval shipboard use are very durable, but many are heavy and are labor intensive when they must be removed or repaired. Many Navy ships are weight critical, in Stability Status II, indicating that no additional weight may be added without full weight and moment compensation. Lighter weight coverings will help alleviate this condition and provide for greater flexibility in the construction of new vessels. Durability and maintainability are key factors in today's Navy where reductions in manning requirements are being investigated to reduce the overall costs of operating ships at sea. Durable and easily maintained/repaired coverings will help reduce the manning required and free up sailors to perform ship operation functions vice maintenance. Additionally, the business of operating Naval combatants is an inherently noisy undertaking. Reducing ambient interior noise levels will have a significant impact on improving the quality of shipboard life and reduce the amount of noise related hearing loss damage suffered by the crew.

PHASE I: Develop and demonstrate feasibility in accomplishing preliminary testing of the covering as a proven concept. Feasibility shall include meeting key performance parameters of being lightweight, durable, maintainable, repairable, noise attenuating, flame resistant and non-toxic when exposed to flame. Additionally, the concept design should focus on time and ease of installation, ease of repair, ease of removal, cost of material(s) and labor, need for specialty tools, need for specialty training for installation, and anticipated service life expectancy.

PHASE II: Fabricate covering candidates and produce sufficient materials for each candidate to cover a total of 1,000 square feet of metal substrate. Conduct both standard laboratory and full-size bulkhead/overhead panel prototype tests to establish improved performance characteristics. Exercise cost model based on development and prototype testing experience.

PHASE III: Full scale demonstration and develop transition plan from research project to full-scale production.

COMMERCIAL POTENTIAL: Coverings are used in many similar areas on commercial applications, such as offshore platforms and commercial vessels where these performance attributes are desirable. An economical covering that meets current industry and military standards while being light weight, durable, easily maintained and reduces transmitted noise, has a wide range of applications that are commercially viable.

REFERENCES:
1. Naval Ship General Specification (GENSPECS) 621 (Non-Structural Bulkheads), 631 (Painting), 632 (Metallic & Non-Metallic Enriched Coatings), 634 (Deck Coverings), 635 (Insulation), 637 (Sheathing)

KEYWORDS: Covering, Overhead, Bulkhead, Lightweight, Attenuating, Maintainable

N02-014 TITLE: Lightweight Joiner Panels

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT ID: PEO-Aircraft Carriers; PMS 378 – CVN(x) Next Generation Nuclear Aircraft Carriers

OBJECTIVE: Explore and develop a lightweight, cost-effective, easily installed marine joiner panel for use as ship

space divider.

DESCRIPTION: Joiner panels today on Navy ships are either thin steel with welded rib stiffeners or narrow extruded integrally stiffened 6061 aluminum panels joined together. They provide a low cost space divider that will withstand the rigors of naval ship environment. New technology developed during the last decade could provide the opportunity for reducing the weight and cost of these panels.

PHASE I: Develop the concept and demonstrate feasibility for use of an ultra lightweight shipboard joiner panel in compliance with General Ship Specifications section 621 and the Habitality Materials List Revision K (NOV 1996). The concept design should focus on time and ease of installation, ease of reconfiguration, and being cost effective.

PHASE II: Fabricate the most promising panel type(s) from Phase I to determine full-size capability, evaluate fabrication techniques, investigate joining methods and repairability. Fabricate simulation structures and expose to tests to determine if they meet the various requirements. Evaluate and design panels to meet the functional requirements for joiner panels. Assess the impact of each technology on the acquisition and life cycle cost.

PHASE III: Design and fabricate a full size structure for ship insertion. In conjunction with PMS 378 select an application, fabricate the joiner panel and insert on an active ship as a demonstration. Monitor the installation and the component during its trial period.

COMMERCIAL POTENTIAL: Commercial ships utilize joiner panels to divide spaces. The technology developed in this program would carry over to the commercial ship community.

KEYWORDS: Joiner; Divider; Bulkhead; Metallic; Walls; Panels

N02-015 TITLE: Development of High Temperature Barrier Coating

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO Carriers

OBJECTIVE: Explore and develop, if feasible, a cost effective, high temperature barrier coating for use on ship bulkheads and structures.

DESCRIPTION: The Navy has need for a cost effective coating that can be used to guard bulkheads and other structures from exposure to high-temperatures during a fire event. The use of new types of lightweight materials will also require the use of barrier coatings to prevent them from reaching elevated temperatures during a fire situation, which will significantly reduce their strength. The coatings should be easily applied by shipbuilder or installation activity and repairable at sea. The coating should meet the fire requirements of UL 1709 and prevent the covered materials from reaching a temperature of 225-250°F above ambient temperature. The coatings should be environmentally compliant.

PHASE I: Explore environmentally safe, high temperature barrier coatings and coating technology for naval applications. Demonstrate through laboratory tests the coating's ability to meet the fire and insulation requirements. Develop a cost model for the coating candidates. Provide samples of a laboratory-sized batch of the barrier coating on parts and resulting test data at the end of Phase I.

PHASE II: From the coating candidate barrier coatings demonstrated in Phase I, supply sufficient amounts of each candidate coating to demonstrate ease of application. Test each coated panel to reaffirm its fire protection capability. Conduct both standard laboratory and full-scale prototype tests to establish baseline properties of the commercially produced product. Exercise cost model based on development and prototype testing experience.

PHASE III: Develop the formulation specification for acceptable high temperature barrier coatings. Develop full

production-scale product and commercialize coating.

COMMERCIAL POTENTIAL: Barrier coatings are used in many areas that have significant fire potential, such as offshore platforms, commercial vessel engine rooms, high risk work zones like welding and forging areas and in many buildings to guard structural members. An economical high temperature barrier coating that meets current industry and military standards has a wide range of applications that are commercially viable.

REFERENCES:

1. UL 1709

KEYWORDS: High-Temperature Coating, Barrier Coating, Fire Coating, Insulation, Thermal Insulation

N02-016 TITLE: Rapid Cryogenic Cooldown Engine

TECHNOLOGY AREAS: Materials/Processes, Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO-MUW; PMS 210-Airborne Mine Defense Program

OBJECTIVE: To increase organic mine sweeping effectiveness by decreasing the preparation time required to deploy superconductive magnetic influence mine countermeasures systems. Provides a key enabler to the insertion of superconducting technology to the Organic Airborne and Surface Influence Sweep (OASIS), Acquisition Category (ACAT) II program.

DESCRIPTION: Superconductive influence mine countermeasures systems have been demonstrated to be rugged and reliable in previous field demonstrations such as MARCOT 97 and Kernal Blitz 98. The evolutionary nature of this technology enables a spiral acquisition approach to achieve improved performance with each generation. These systems must be kept below -196o C to be superconductive. Onboard cryocoolers can maintain this temperature. However, the critical weight limitations of the OASIS system prevents installation of excess refrigeration capacity to quickly cool the system from room temperature to operating temperature, increasing the time required to prepare the system for deployment. This SBIR is to develop the technology required for a portable, temporary cooldown engine that can be used with the OASIS system to decrease the preparation time required to deploy a superconductive system.

PHASE I: Perform the preliminary system design for a cooldown engine that could interface with an OASIS towed body. This system should be compatible with both high and low temperature superconductors to permit the selection of the best superconductor for the system. The cooldown engine should take into consideration shipboard and flightdeck conditions and requirements. The system should require minimal maintenance, minimal formal training to operate, and be automatic.

PHASE II: Perform the detailed design and build a demonstration unit to enable an assessment of the cooldown engine in a laboratory environment.

PHASE III: Incorporate the lessons learned from Phase II into the detailed design. Build a prototype cooldown engine and demonstrate it at sea. Develop a marketing survey for cooldown engines and determine other potential commercial markets that could reduce the life cycle costs associated with a module.

COMMERCIAL POTENTIAL: This concept could be also used to provide rapidly deployable superconductive communication antennas.

REFERENCES:

1. OASIS Analysis of Alternatives (AoA) dtd 31 May 2000; Operational Requirements Document (ORD) for OASIS, Serial No. 572-75-01, dtd 10 January 01

KEYWORDS: Cryogenics, Cooldown Engine, Low Temperature Superconductivity, High Temperature Superconductivity

N02-017 TITLE: Classification Enhanced Target Tracking

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: PEO MUW – Mine Undersea Warfare

OBJECTIVE: Develop and demonstrate an acoustic sensor reduced false alarm rate tracking algorithm with augmented classification feedback acoustic tracks.

DESCRIPTION: Current sonar system tracking algorithms tend to provide relatively large sets of acoustic tracks for display to the watchstander. Many of these tracks are false tracks. The watchstander, in this situation, must evaluate each track leading to possible work overload. Simply changing track threshold(s) does not resolve the problem. Lowering the threshold(s) enhances the opportunity of forming tracks for lower signal to noise or signal to interference threats. The downside is additional tracks are formed exacerbating watchstander frustration. Increasing track threshold(s)does not solve the problem. Increasing the track threshold(s) reduces false track generation, but also lowers the probability of forming a track on a low signal to noise ratio or signal to interference ratio threat. Not forming a threat track could be fatal to ownship survival. Sonar track algorithms with classification clue feedback are required to resolve the track threshold false alarm and threat fail-to-notice issues.

PHASE I: Develop the classification clue feedback track algorithm. Model the algorithm and evaluate its performance with simulated data in a number of modeled acoustic environments.

PHASE II: Determine theoretical algorithm performance and compare against existing algorithms using acoustic data from the NUWC TASAD data base. Conduct a limited amount of at-sea experiments comparing current algorithms to the enhanced algorithm.

PHASE III: Conduct extensive at-sea testing, during which Navy watchstanders are invited to participate in algorithm evaluations. Prepare the algorithm for introduction to fleet sonar systems, develop training techniques, and prepare a full set of documentation to support the algorithm and its use when it is transitioned.

COMMERCIAL POTENTIAL: This technology could by used by the FAA to track aircraft.

REFERENCES:
1. Bar-Shalom, Y., Chang, K.C., and Blom, H.A.P. (1990) Automatic track formation in clutter with a recursive algorithm. In Y. Bar-Shalom (Ed.), Multitarget–Multisensor Tracking Advanced Applications, Dedham, MA, Artech House, 1990.
2. Lerro, D., Bar-Shalom, Y., Interacting Multiple Model Tracking with Target Amplitude Feature, IEEE Transactions on Aerospace and Electronic Systems, Volume: 29, Issue: 2, Page(s) 494-509
3. Willett, P., Niu, R., Bar-Shalom, Y. Integration of Bayes Detection with Target Tracking, IEEE Transactions on Signal Processing, Volume: 49 Issue: 1, Jan. 2001, Page(s): 17 -29

KEYWORDS: Sonar, Tracking, False Alarm, Classification, Algorithm, Watchstander

N02-018 TITLE: Statistical Operator Workload Allocation to Maintain USW Performance

TECHNOLOGY AREAS: Information Systems, Materials/Processes, Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: PEO MUW – Mine Undersea Warfare

OBJECTIVE: Develop and test workstation automation that distributes available operator workload to maximize performance of contact detection, classification, and localization in areas of high tactical significance.

DESCRIPTION: A primary component in the total cost of ownership of the Navy's surface ship combatants is the cost of manning the platforms. Platforms of the future, such as DD 21, have a requirement to reduce the manning necessary for the conduct of Undersea Warfare (USW) missions by operating the entire USW suite from a single operator workstation. This will be done by automating many functions currently performed by human operators, such as target detection, classification, and localization (DCL), data fusion, and routine operator functions performed at the workstation, such as display configuration.

Historically, automated processing of acoustic sensors has produced an excess of false alarms such that even with multiple operators, workload exceeds operator capabilities, particularly in multi-contact, littoral environments typical of regional conflicts. Even as automated DCL and data fusion systems improve, it is likely that the USW operator will be overloaded under some tactically realistic conditions. Further, for the foreseeable future, some degree of operator confirmation will be required to provide sufficient confidence in machine decisions for tactical response. Therefore, under circumstances of operator overload, the performance of the USW combat system is limited not by the performance of the system in detection, localization, and classification of legitimate targets, but by the ability of an operator to assess those decisions in a timely manner when faced with an excess of false contacts. It is likely that in any tactical situation the density of contacts, the time required to verify or dismiss machine decisions, and the tactical significance of contacts will vary with their location in the battlespace. The attributes of individual contacts also provide a basis for assessing tactical significance.

To address these issues, the Navy seeks innovative techniques for the automatic allocation of operator workload such that system performance (possibly weighted by a cost function representing tactical significance) is maximized across the USW area of interest. For example, the workstation automation might direct operator attention away from areas of low tactical significance or locations where environmental conditions support accurate machine decisions and favor areas where a priori information indicates target detection is likely or the operator has consistently overridden machine decisions. It is expected that operator workload allocation algorithms would include: (1) methods of designating tactical significance based upon contact attributes and a priori information: (2) estimating contact load and operator workload as a function of geographical location in the battlespace, (3) development of appropriate performance criterion functions, and (4) evaluation of numerical optimization techniques for the assessment candidate operator work distributions. Direct search techniques, such as Pattern Search, have been shown to be particularly appropriate for the optimization of complex criterion functions [1].

PHASE I: Define an operational scenario, appropriate performance criteria, and practical means of directing operator workload for a USW workstation, focusing on the Detection, Classification, and Localization (DCL) function. Estimate the improvements in tactical performance achievable through workload distribution for several tactical situations.

PHASE II: Develop a practical optimization technique for Statistical Operator Workload Allocation (SOWA), implement the algorithms in a selected USW Workstation environment (such as the IUSW-21 ADM Workstation) and evaluate DCL performance with recorded data or in during an at-sea test.

PHASE III: Prepare the algorithms and workstation for introduction to fleet sonar systems, develop training techniques, and prepare a full set of documentation to support the system when it is transitioned.

COMMERCIAL POTENTIAL: Air Traffic Control is an ideal candidate for use of this technology.

REFERENCES:
1. Hooke and Jeeves, "Direct Search Solution of Numerical Optimization Problems," Journal of the ACM, Vol. 8, No. 2, 1961, pp. 212-229

KEYWORDS: Operator Workload, Workstation Automation, Situation Awareness, False Alarm Rates, Undersea Warfare, Detection, Track, and Classification (DCL)

N02-019 TITLE: Robust Ultra High Frequency (UHF) Satellite Communications Protocol for UUVs

TECHNOLOGY AREAS: Information Systems, Sensors

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II: (PEO-MUW – Mine Undersea Warfare); UUV Program Office (PMS403)

OBJECTIVE: As the U.S. Navy integrates all platforms into IT-21 Network Centric Warfare, the Unmanned Undersea Vehicle (UUV) Programs require interoperable, high data rate, low bit error rate (BER), and robust communications. Communications between the UUVs and other platforms are required to provide timely mission data and also allow the modification of pre-planned UUV mission parameters. It is intended that UUVs be provided with Ultra High Frequency Satellite Communications (UHF SATCOM) while operating near the surface in both Open Ocean and Littoral environments. UHF SATCOM will provide the capability necessary for over the horizon, long endurance UUV missions.

UHF SATCOM system implementation possibilities become limited as the UUV is a power and volume constrained platform. UUVs under development implement the communication function by deploying a retractable telescoping mast assembly with an UHF antenna. The small physical aperture available for the antenna, small height above the waterline, and minimal transceiver power availability limit system performance.

In addition to performance limitations due to communications system sizing, the UUV motion on the surface in various sea states increase the probability of data loss due to antenna washover and/or antenna attitude variations. Unlike submarine mast mounted UHF antenna systems, the UUV UHF systems are in direct proximity to the seawater when deployed and operating. Accordingly, degraded performance by multi-path effects, wave shadowing, water on the antenna, and direct coupling of the non-uniform sea into the dielectric region of the antenna element results in de-tuning. The degradation modes are collectively referred to as washover. This is a UHF COMMS channel that can be more closely described as a multiplicative or fading channel than as an Additive White Gaussian Noise Channel (AWGN). The distinction between an AWGN channel and a multiplicative channel is important when quantifying channel performance and mitigating environmental effects. Any UHF SATCOM user with a multiplicative channel can be considered disadvantaged.

The Navy is interested in developing a communication protocol that will provide disadvantaged users (UUVs, communication relay buoys) the ability to maintain communications in environmental conditions up to sea state 4.

DESCRIPTION: The Navy is interested in researching, evaluating, and implementing advanced communications methods to provide significant data rates at a BER of 10-5 or better in the disadvantaged channel for implementation into a UUV UHF SATCOM transceiver or on-board computer. The effort will maximize data throughput to minimize time required for on-surface communications operations (i.e. to minimize the vulnerability).

PHASE I: Develop a system design concept for mitigation of the UUV communications performance degradation caused by the sea state environment. The study shall establish the UHF SATCOM requirements for UUV operations in a sea state: data product analysis; data rate and BER evaluation; link budget analysis; and simulation, modeling, testing, and evaluation of the degradations in performance to the UUV UHF SATCOM channel. Initial studies shall define a recommended signaling technique(s) and system architecture identifying any impacts to existing UUV UHF SATCOM infrastructure, data rate and BER capabilities, and latencies.

PHASE II: Fabricate and test brassboard and prototype – hardware/software subsystem components to validate mitigation strategies for the degradations due to the sea state environment. The tests should demonstrate link capabilities in controlled simulation, laboratory, and at-sea environments.

PHASE III: Provide a tested prototype system along with associated documentation for integration and testing into a UUV test vehicle.

COMMERCIAL POTENTIAL: This system could be applied to work requiring UHF communications with limited size and power in highly dynamic environments.

REFERENCES:

1. The Navy Unmanned Undersea Vehicle (UUV) Master Plan, April 20, 2000.

KEYWORDS: Unmanned Undersea Vehicle, UUV, Communication, Protocol, UHF

N02-020 TITLE: Remote Controlled Non-Gasoline Burning Water Craft

TECHNOLOGY AREAS: Ground/Sea Vehicles

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IV: PEO-Expeditionary Warfare (PMS 325)

OBJECTIVE: Develop non-gasoline burning engine technology for small watercraft for use as a remotely operated surface target, representative of a small boat threat.

DESCRIPTION: The development of non-gasoline burning engine technology for small watercraft is essential for military use. The Department of Defense has directed that no new combat support, combat service support equipment or vehicles requiring gasoline-type fuels will be acquired or developed unless the support concept is to supply fuel as a packaged product. It is imperative, therefore, that non-gasoline burning engines be developed for various small watercraft applications. This topic is primarily concerned with the development of a non-gasoline burning watercraft for use as a remotely operated surface target. Remote control technology for operation, control and monitoring of a watercraft has previously been developed. Therefore, the focus of this topic is to develop a watercraft capable of burning No. 2 Diesel, Naval Distillate Fuel (NATO F-76), JP-5 (NATO F-44), and JP-8 (NATO F-34), and is adaptable to the already developed remote control technology. It is desirable that the watercraft be similar in size to a typical commercially available two- or three-seat personal watercraft, with a desired cruise speed of 30 knots. This remote-controlled surface target must be ship deployable and expendable.

PHASE I: Conduct feasibility studies and develop a concept design for a non-gasoline burning watercraft capable of remote control operation.

PHASE II: Develop, demonstrate and test the non-gasoline burning watercraft prototype capable of remote control operation.

PHASE III: Address any conceptual or design issues. Produce full-scale and market the non-gasoline burning watercraft.

COMMERCIAL POTENTIAL: A non-gasoline burning watercraft would be marketable to diesel powered recreational and fishing yachts that regularly carry a personal gasoline burning watercraft onboard, thus eliminating the need to carry both diesel fuel and gasoline. Also, remote controlled non-gasoline burning personal watercraft can be fitted with cameras suitable for unmanned surveillance of harbors, marinas, and waterfronts at industrial facilities.

REFERENCES:

1. Non-gasoline Burning Outboard Engine (NBOE) Program- Coastal Systems Station, Dahlgren Division, Naval Surface Warfare Center; 6703 West Highway 98, Panama City, Florida 32407-7001; NSWC CSS Public Affairs Office (850) 235-5107.

KEYWORDS: Surface Target, Jet Ski, Diesel, Engine, Non-Gasoline, Watercraft, JP-5, JP-8, Roboski

N02-021 TITLE: Fluorescent Light Compression/Containment

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes

OBJECTIVE: Design, develop and demonstrate an innovative and compact shipboard system to dispose of used fluorescent lights and safely contain the hazardous gases. This devise will decrease the storage volume of spent fluorescent lights and safely contain the hazardous gases such as mercury vapors.

DESCRIPTION: Naval ships use fluorescent lighting and accumulate a large volume of spent fluorescent lights that must be safely stored onboard awaiting disposal. These fluorescent lights are considered hazardous waste because they contain mercury vapor. Storage requires a large volume of precious shipboard space and the lights must remain intact to contain the hazardous gases. Design, develop and demonstrate an innovative system/process that will dispose of the florescent lights to reduce the volume and safely contain the hazardous gases separately. Additional attributes of the system should include: compactness, ease of operation, ease of maintenance, ease of repair and suitability for shipboard environment (corrosion resistance, ability to withstand shock and vibration and sturdiness to withstand sailor abuse).

PHASE I: Design/develop/demonstrate proof of concept and include a preliminary design. The final product will be a detailed report describing this technology and how it solves the storage and disposal problem.

PHASE II: Design, build and test (land-based and shipboard) a full-scale prototype unit. Prepare and deliver final report of land-based and shipboard test and evaluation.

PHASE III: Develop performance specifications. Prepare cost estimates for production units. Begin production for large Navy surface ship use. Product should be made commercially available by the close of Phase III.

COMMERCIAL POTENTIAL: This will be of value to all industries that use fluorescent lighting and must safely dispose of the spent fluorescent tubes. Wide spread applications in all industries.

REFERENCES:

1. MIL SPEC MIL-S-901C
2. MIL-STD-167-1
3. OPNAV INSTR 5100.19C; Chapters B3 and B13

KEYWORDS: Environmental, Storage, Shipboard, Containment, Fluorescent Lighting, Hazardous Waste

N02-022 TITLE: Front-end Controller for an Intelligent Synthetic Forces Simulation Engine

TECHNOLOGY AREAS: Information Systems, Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IV: PMS 430 (Battle Force Tactical Training Program)

OBJECTIVE: Provide a means of employing Intelligent Synthetic Forces in Training Simulation Scenarios.

DESCRIPTION: The Battle Force Tactical Training (BFTT) System is currently being deployed aboard US Navy surface combatant ships to provide coordinated, realistic, high stress combat team training. The BFTT System generates and maintains a realistic synthetic battle space consisting of simulated forces such as air, surface and subsurface platforms, sensors and hard- and soft-kill weapons, as appropriate to the training event. The constituents of the synthetic battlespace and their behaviors are based upon pre-scripted simulation scenarios that are selected and tailored by the ship's training team based on each event's objectives. The current state of the art in training simulations requires operator-intensive scenario scripting and monitoring, resulting in rigid, non-interactive entity behavior.

Recent advances in Intelligent Synthetic Forces (ISF) offer the potential of composing scenarios using flexible vignettes,

rather than pre-scripted motions and behaviors. Such flexible vignettes could consist of standard mission- or task-specific behavior models without reference to specific platform type, geographic region, or tactical situation. These mission-specific parameters could be set immediately prior to or during the actual scenario execution, without requiring any further human intervention. This has the potential of reducing the training team's workload while at the same time increasing realism by enabling synthetic forces to react to the training audience's actions.

To realize this potential, a means is needed that will enable the BFTT System to specify, tailor, and initiate ISF-based flexible behavior models as components of an overall event scenario script.

PHASE I: Develop an approach and demonstrate the feasibility of constructing training simulation scenarios from flexible vignettes. Examine shipboard training simulation requirements and categorize the synthetic entity behavior parameters that are susceptible to being fixed at the time of scenario script generation. Develop and document a data exchange protocol that will support the specification and tailoring of an intelligent synthetic forces model.

PHASE II: Develop, test and demonstrate a prototype ISF simulation system. The prototype should consist of an ISF controller connected to the selected ISF simulation engine, modified as necessary to support the interface in accordance with the data exchange protocol developed under Phase I. The demonstration should include several different missions or tasks and several different platforms.

PHASE III: Develop a production ISF simulation system that can be integrated into the BFTT System and/or similar simulation based training systems.

COMMERCIAL POTENTIAL: An intelligent synthetic forces simulator that reduces operator workload and allows flexible scenario composition is needed in a variety of military training environments by all three services. This capability is also required by the militaries of US allies and friendly nations, as well as by non-military organizations, such as medical and paramedic, law enforcement, disaster assistance and crisis management agencies.

REFERENCES:

1. R. Pew and A. Mavor (eds): Modeling Human and Organizational Behavior: Application to Military Simulations, National Academy Press, Washington DC 1998.

KEYWORDS: Training, Modeling & Simulation, Synthetic Forces

N02-023 TITLE: Shipboard Power Conversion

TECHNOLOGY AREAS: Materials/Processes, Electronics

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT ID: PEO(SUB) PMS401 – Warfare System Engineering Program Management Office

DESCRIPTION: The continued, though decreased, utilization of 400 Hz power for legacy equipment in submarine shipboard equipment applications necessitates some subsystem provisioning of 400 Hz power supplies using 60Hz ship's power as the input source. This SBIR effort is to provide an innovative modular power converter design that will accommodate the limited quantity of 400 Hz submarine shipboard equipment power requirements. The initial focus is on power conversion in support of weapons. The overall goal is to have a modular approach to power conversion that can be adapted to various uses across all submarine classes. The resulting approach must meet submarine reliability, environmental and volume constraints while minimizing recurring cost.

PHASE I: Research power requirements and current methods of power conversion, and develop alternative approaches. Alternative approaches should be cost effective, low risk, and meet all requirements.

PHASE II: Develop, prototype, and test alternative power conversion in a VIRGINIA Class Weapon Interface Panel to prove power conversion requirements are met. Identify how this technology could be extended to other uses on various

classes of submarines.

PHASE III: Complete the design and manufacture power converters for use shipboard.

COMMERCIAL POTENTIAL: The technology being developed may be adaptable to some commercial power conversions.

REFERENCES:

1. VIRGINIA Common Specification for Sonar, Combat Control & Architecture Subsystem Common Spec-01 Revision C 27 August 1999 with Specification Change Notice (SCN)1 23 March 2000.
2. Weapon Power Converter Procurement Specification, dated 5/15/01
3. NSSN WLC Weapon Power Converter (WPNPC) Installation Drawing, DWG #G646537 Rev D.
4. NSSN Class Submarine Weapons Launch Console Integrated Enclosure Interface Control Drawing.
5. Interface Control Drawing Between The New Attack Submarine (NSSN) Command, Control, Communications & Intelligence (C3I) System And The 60 Hertz Electrical Power Distribution System, NAVSEA DWG NO. 53711-6659075 Rev C, dated 20 December 1996.
6. Interface Standard for Ship Systems, MIL-STD-1399/300A, 13 October 1987
7. Military Specification, Power Supply, Rectifier, Interior, MIL-P-15736/5, 9 August 1985
8. Navy Power Supply Reliability Design and Manufacturing, NAVMAT P-4955-1A

KEYWORDS: Power Conversion, 60 Hz to 400 Hz

N02-024 TITLE: Automated/Simplified Weapons OMI

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IV: PMS425-Combat Control System & MK2 Program

OBJECTIVE: The objective of this topic is to investigate new communications paths and the use of an advanced set of algorithms/models that can reduce the time from acquisition of a target to time of fire. Use of innovative, legacy and new algorithms/models (e.g., contact correlation, preset evaluation, etc.) will be used as the basis for the simplification of weapons deployment operator machine interface.

DESCRIPTION: The developer will develop innovative communication concepts, (i.e. wireless) and provide for environmental correlation algorithms between combat control systems and the weapon including weapon presets, displays, and postlaunch. Currently, the activities associated with weapons launch -- contact correlation, weapon preset/evaluation, weapon preset assignment and post-launch target motion analysis -- are manually intensive, time-consuming and subject to human error. Development of innovative algorithms/models and improved automation of these functions would simplify the weapon launch process, resulting in improved tactical control. This technology will improve weapon lethality, guidance and control, and information management and seamless communication. These advances could be used in other DOD programs and in other services.

PHASE I: Research and define the critical parameters required in generating timely, relevant and coherent algorithms/models and communications processes for weapons deployment support tools for use in making command level weapons deployment decisions. Research and define innovative communications, algorithms/models and processes associated with Weapons Deployment Tools to satisfy major requirements related to legacy tactical functions, interfaces, and real-time performance requirements. Research and define innovative, cost-effective solutions. At the end of the Phase I, a business case, approach, high level design, and technology profile will be selected for further research.

PHASE II: Fabricate and demonstrate a prototype employing the techniques defined in Phase I, using Phase I specified products to be performed and measured against the critical parameters developed in Phase I.

PHASE III: A full system design will be developed, applying the principles generated in the previous phases, to meet tactical requirements.

COMMERCIAL POTENTIAL: Use of a commercial technologies (i.e. wireless, fiber optic) will facilitate the infusion of COTS products and open system interfaces into tactical systems, which is of benefit to the commercial hardware manufacturers and software developers. Use of innovative and open standards approaches will facilitate the infusion of NDI, GOTS and COTS option reduction products. Use of open system interfaces into tactical systems benefits commercial hardware manufacturers and software developers. Additionally, this technology has potential applicability for commercial use in the transportation industry including navigation and aircraft.

REFERENCES:

1. PMS4253-001 System Specification for the CCS MK2 Program DO Block 1C (Mods 0/1/2/3)
2. Adcap Torpedoes WOG Background software Requirements Specification 15 Dec 1998 (Confidential)
3. AdcapTorpedoes WOG foreground software requirements specification 15 Dec 1998 (confidential)
4. Submarine Tactical Requirements Group (STRG) ltr. Ser 8510 N72/S0001 of 7 Jan 00

KEYWORDS: Submarine, Weapons, COTS, SSN, VME, Real-Time, Wireless, Fiber Optic

N02-025 TITLE: Non-collinear Wave-front Curvature Range Measurement

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT III: (PMS425) Acoustics-Rapid Cots Insertion (A-RCI)

OBJECTIVE: Passively measure the distance to the source of an acoustic emission using broadband sensors that are not mounted collinearly.

DESCRIPTION: Wave-front Curvature Ranging (WCR) ranging techniques currently require that sensors be separated by the maximum distance possible and be accurately located along the same line in 3-D space (collinearly) on the submarine. This creates difficult and expensive installation problems, and precludes attempts to utilize other available sensors not located in the same line. Implementing a Non-collinear WCR approach will alleviate these limitations.

PHASE I: Develop a report with a proposed solution supported by studies and analyses that will achieve the objective in the submarine acoustic intercept frequency band (generically 1Khz-100KHz). The report should include a comprehensive plan to develop either a simulation or prototype of the proposed solution, depending upon the technical maturity of that proposed solution. The report must address the testing requirements and how the simulation or prototype will meet them. The Contractor's proposal should provide an estimate of the maximum effective range and accuracy of the proposed capability across the acoustic frequency spectrum.

PHASE II: Develop the approved Phase I solution. The solution (simulation or prototype) will be tested to the Phase I testing requirements. That testing would then result in either a design for a specific ship class installation prototype (in the case of a simulation) or a test report (in the case of a prototype) leading to changes for the development of a retrofit kit for a specific ship class installation. In either case the software and hardware products should be compatible with existing submarine acoustic systems architecture under the Acoustic Rapid COTS (Commercial Off-the-Shelf) Insertion (A-RCI) Program.

PHASE III: For a Phase II simulation, Phase III would develop a prototype that would be tested on a specific ship class, with the result, a mature manufacturable design for that particular class. For a Phase II prototype, Phase III would consist of an Engineering Change Proposal (DD1692-1 or 1693) for ARCI implementation of a productized design.

COMMERCIAL POTENTIAL: This solution should be applicable to both submarine and surface ships, and may offer

applications in ocean geological and environmental studies and subsequently facilitate a greater understanding of the ocean environment, commercial fishing and mineral resource exploration by providing 3-dimentional passive localization of all water-born acoustic signals, including those of marine life.

REFERENCES:

1. "Source Localization of Short-Duration signals Using Wave-Front Curvature" Technical Report to NUSC, Contract Number N66604-91-C-7043; Authors Dr. Ben Rosen, Dr Michael S. Wengrovitz; Atlantic Aerospace Electronics Corp.
2. "Radius of curvature estimation and localization of targets using multiple sonar sensors." Billur Barshan Department of Electrical Engineering, Bilkent University, Bilkent, 06533 Ankara, Turkey;Ali S¸ afak Sekmen
3. Center for Intelligent Systems, Department of Electrical and Computer Engineering, Vanderbilt University, Box 1824, Station B, Nashville, Tennessee 37235. Acoust. Soc. Am., Vol. 105, No. 4, April 1999

KEYWORDS: Radius of Curvature (ROC) Ranging, A-RCI (Acoustic Rapid COTS Insertion), Wave front Curvature Ranging (WCR), Acoustic Intercept, Broadband Sensors, Processor, Software Configuration

N02-026 TITLE: Sealing Method for Odor Barrier Bags (OBBs)

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: PMS450 – SSN774 VIRGINIA Class Submarine

OBJECTIVE: To develop a cost effective method to seal Odor Barrier Bags to facilitate onboard storage of plastic waste without degrading crew quality of life.

DESCRIPTION: The Act to Prevent Pollution from Ships (APPS) requires the U.S. Navy to retain all plastic waste for shore disposal. Since most of the plastic waste generated at sea is food contaminated, the Navy developed management procedures that require the waste to be stored in heavy weight plastic bags to form an odor barrier. These bags, called Odor Barrier Bags (OBBs), are currently sealed with either an adhesive tape, or by the use of a heat sealer, which have several shortcomings:

The adhesive sealed bags are difficult to make effective air-tight seals, are expensive, and require additional storage space (non-adhesive bags are provided on a roll, while the adhesive bags come in a box).

The current heat sealer (Doboy HSB II) is prone to failure, labor intensive, expensive, and a potential safety hazard. In addition, user feedback has indicated that the seal width is too narrow and the unit is awkward to use.

A need exists to develop an improved method to achieve air-tight OBB seals that is cost effective, quick, and safe.

PHASE I: The contractor will research technology that can demonstrate effective sealing OBBs that will not degrade crew quality of life, increase workload, and is rugged enough to withstand the shipboard environment. The contractor will deliver a report defining the approach for the proposed technology and the associated operational procedures/management plan.

PHASE II: Following acceptance of the contractor's report to the Navy, the use and feasibility of the proposed technology will be demonstrated in the laboratory and at-sea on a Navy vessel.

PHASE III: Develop a standard operating procedure for the use of the recommended technology and provide technical support and consultation to the Navy to ensure its acceptance and implementation.

COMMERCIAL POTENTIAL: The technology may be adapted for use in the commercial shipping industry, food industry, recreational boating, and additional areas/applications where a reliable, cost effective means is needed to seal

materials in OBBs.

REFERENCES:

1. National Stock Number of OBBs (Non-adhesive): 8105-01-392-6510 (Small OBB), 8105-01-393-6515 (Large OBB)
2. Proposed submarine Odor Barrier Bags: Curlon Grade 9450-MM, 10 mil coextruded film, Manufactured by: Curwood, Inc., A Bemis Company, 718 High Street, New London, WI 54961

KEYWORDS: Plastic, Waste, OBB, Disposal, APPS, Heat Sealer

N02-027 TITLE: Submarine Rescue Chamber/Hold-down Installation Via Underwater Friction Stud Welding Using Atmospheric Diving Systems

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: PMS 350/395; Advanced Seal Delivery System (ASDS)/Seal Support System

OBJECTIVE: Develop a system that is capable of welding studs to a disabled submarine at depths beyond current capabilities that would allow for attachments to support the Submarine Rescue Chamber (SRC) and Deep submergence Rescue Vehicle (DRSV) and provide a means for life support and gas sampling using a hot tap process.

DESCRIPTION: Lessons learned from the sinking of the KURSK showed the need for developing the capability to attach a downhaul/hold-down device to a stricken submarine in addition to providing life support gas. Rescue of the KURSK was hampered by lack of welding capabilities beyond 100fsw and military diving capabilities beyond 300fsw. Underwater friction stud welding is a mature process that has proven capabilities for producing sound welds at 1300fsw. Atmospheric diving is also a mature process with proven capabilities to 2300fsw. This project will require interfacing an underwater friction stud welding system to an atmospheric diving system (ADS). Underwater welding of any process has never been attempted using an ADS. The challenge is designing fixtures that will aid the ADS in the manipulation of the friction stud welder along with semi-automatic insertion of the studs into the welder. The friction stud welder requires a restraining mechanism that can be achieved by electro-magnets, vacuum pads, or mechanical restraint. The best method for restraining the welder to the hatch area of the submarine will have to be determined and developed for use with the ADS. Tooling and fixtures will also have to be developed for aligning and placing a pad-eye onto a rescue hatch of a submarine along with developing the hot tap process.

PHASE I: Develop a system design for interfacing the friction stud welding system to the ADS plus all required tooling and fixtures for attachments to a submarine hatch. In addition, design a hot tap process using hollow studs friction welded to the pressure hull of a submarine.

PHASE II: Prototype and test at a minimum depth of 1300fsw to prove the capability to attach a pad-eye onto a hatch, and perform a hot tap process.

PHASE III: Standardize design for use on all classes of submarines, US and foreign. Adapt for use on off-shore oil platform repairs.

COMMERCIAL POTENTIAL: Off-shore oil platform repairs that currently require saturation diving and dry chamber welding to effect.

REFERENCES:

1. Murray, R.I., Underwater Friction Stud Welding: American Bureau of Shipping, International Workshop on Underwater Welding of Marine Structures, December, 1994, p, 177-187
2. Hard Suit Manual, MAN-HS2-THA, Hard Suits Inc., North Vancouver, British Columbia, Canada V7J-1J3.

KEYWORDS: Diving, Welding, Rescue, Submarine, Friction Stud Welding

N02-028 TITLE: Advance Algorithm for Total Ship Monitoring Improvements

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: NAVSEA 93/ASTO: SSN-688 Total Ship Monitoring System

OBJECTIVE: To develop innovative processing and analysis techniques which improve the diagnostic and localization capability of submarine total ship monitoring (TSM) systems.

DESCRIPTION: TSM systems to be installed on submarines include extensive acoustic sensor networks to detect radiated noise. Current plans will upgrade TSM telemetry and processing hardware but there are no planned efforts to upgrade TSM signal processing and analysis capability. Existing TSM processing is rudimentary and reflects resource limitations of legacy processing systems. Innovative processing and analysis techniques are sought to improve the effectiveness of TSM systems in detecting, classifying, and localizing unwanted radiated noises. Potential techniques might include spectral analysis methods for non-stationary signals, neural net or fuzzy logic classification algorithms, machinery signature analysis, processing between internal hull mounted and external noise monitoring or sonar sensors, processing between ownship and remote sensors, etc. The Navy's goal is to achieve the most diagnostic and vulnerability information possible from the extensive TSM sensor data available.

PHASE I: Develop specific processing techniques to improve TSM diagnostics. Explain the theoretical basis and develop a limited prototype processor for proof of principle.

PHASE II: Develop a limited scale processor that can process recorded TSM data in a lab environment. Process recorded data for algorithm optimization and provide metrics for resulting performance.

PHASE III: Develop a production software version of successful TSM processing techniques for integration and back fit with installed Fleet TSM systems.

COMMERCIAL POTENTIAL: The technologies developed on this program have application in industry to monitor industrial processes. It has the potential to reduce the number of operators and watchmen needed to control and manage an automated industrial process. It has potential for detecting failures or anomalous behavior in facilities that are not ordinarily attended.

REFERENCES:

1. W.J. Wang and P.D. McFadden, "Early Detection of Gear Failure by Vibration Analysis", Mechanical Systems and Signal Processing, vol 7,pp. 193-203, 1993.
2. C.L. Nikias and A.P. Petropulu, "Higher-Order Spectral Analysis: a Nonlinear Signal Processing Framework", Prentice-Hall, 1993.
3. W. S. Burdic "Underwater Acoustic Systems Analysis" 2ed Edition, Prentice Hall, 1991. Chapter 12
4. R. J. Urick " Principles of Underwater Sound" 3rd Edition, McGraw Hill, 1983. Chapter 11

KEYWORDS: Vibration Monitoring, Signal Processing, Machinery Analysis, Total Ship Monitoring, Algorithms, Acoustics

N02-029 TITLE: Optimized Detection Performance of Broadband Active Sonar in Non-Gaussian Underwater Acoustic Environments

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop innovative broadband active sonar processing techniques that improve sonar performance by better estimating the statistics of the non-Gaussian underwater acoustic environments to achieve near optimum detection performance.

DESCRIPTION: Existing Navy sonar signal processing assumes that the background statistics are distributed in a Gaussian manner. In narrowband processing, and in the open ocean environment, such assumptions are valid; however, in the shallow water environment, or when broadband processing is performed, it is possible that the background statistics can deviate from a Gaussian distribution. In order to achieve improved performance in these environments, the sonar signal processing should take into account the effects caused by the possibly non-Gaussian background. The Navy seeks to develop innovative signal processing algorithms that explicitly take into account the prevailing (possibly non-Gaussian) statistics to secure near-optimal performance in an adaptive manner.

The developed algorithms, which will ultimately be hosted within a tactical sonar system, should be computationally efficient for real-time processing of broadband active sonar arrays and robust in the presence of unexpected changes in the prevailing statistics of ambient noise and reverberation. The Navy seeks processing techniques to take advantage of non-Gaussian backgrounds in the antisubmarine warfare (ASW) arena at frequencies from 100 Hz to 1000 Hz, in the 1 kHz to 10 kHz region for ASW and mine avoidance, and above 10 kHz for ASW, mine detection, and bathymetry. Algorithms should address one or more of these frequency regimes. The sonar processing bandwidths envisioned range from one or two octaves to approximately a decade.

PHASE I: This phase will be a feasibility study to characterize the potential performance of candidate algorithms for detection gains in non-Gaussian noise and reverberation backgrounds and to model the efficacy of the proposed algorithms with appropriate synthetic and real data. The operational tradeoffs between processing parameters and system characteristics (e.g., bandwidth, processing speed and throughput) will also be defined. The performance improvement in terms of output signal excess, receiver operating characteristic (ROC) curves, or other selected performance metrics will be quantified. Metrics will be developed for the evaluation of the prototype algorithms.

PHASE II: In this phase, the candidate algorithms will be prototyped and used to demonstrate and thoroughly test and evaluate their performance in non-real time laboratory settings using broadband data. The prototype algorithms will be evaluated to determine the processing parameters and computational requirements as a function of operational bandwidth and prevailing statistics of ambient noise and reverberation.

PHASE III: In this phase, the algorithms will be transitioned into tactical sonar suites via processes such as the Advanced Build Process.

COMMERCIAL POTENTIAL: The improved detection performance of broadband active sonar systems equipped with algorithms capable of exploiting the non-Gaussian statistics of the shallow water littorals promise to provide great benefits to the government and Private Sector. Some of the areas where the increased performance of sonars will be of benefit include search and rescue, harbor safety, fish finding and marine resource management, drug interdiction, and a variety of other Coast Guard related activities.

KEYWORDS: Broadband Active Sonar, Non-Gaussian Processing, Adaptive Processing

N02-030 TITLE: Advanced Ship/UAV Recovery, Securing and Handling Interface

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: PEO Surface Strike (DD-21)

OBJECTIVE: Develop and demonstrate a lightweight, inexpensive, mechanically simple ship system for safely arresting vertical takeoff/landing unmanned aerial vehicles (UAVs) upon landing, securing them temporarily and maneuvering them on deck.

DESCRIPTION: Surface combatants employ UAVs to perform a variety of functions. The future population of UAVs is to employ vertical takeoff/landing capability to reduce shipboard impacts. This presents special challenges for shipboard recovery, securing and handling. The presently projected system for arresting and securing UAVs weighing up to 2500 pounds on surface combatants employs a large (approx. 6' diameter, 4" high, >2000 lb) steel grid on the ship's deck. The UAV must carry a 100 lb "harpoon" mechanical locking device that is inserted into this grid. This grid and locking device results in weight, handling and signature issues. The aft, moderately high location on ship compounds the negative aspects of the weight interface. The system requires a powered mechanical action (harpoon locking) to secure the UAV upon landing. The grid may be embedded in the ship's deck, in which case it will infringe on the under deck space allocated. If the grid is portable, stowage of the grid, which is wider than UAV landing gear, will be problematic.

The DD 21, designed for reduced/optimized manning, will not have the luxury of accommodating the extensive manning impact such a system presents. This initiative is intended to elicit a means to positively secure multiple UAVs to a surface combatant's deck upon landing, preferably without a powered system. The system would be capable of remotely releasing UAVs and providing a means to easily maneuver them on deck either for takeoff or for transport into and within a hangar. A shuttle remotely controlled by a crewmember is envisioned as a means, but not necessarily the only means, of raising the UAV and providing deck mobility. Such a system must of necessity offer low acquisition and lifecycle costs, be mechanically simple, and provide for safe ship operation in a variety of shipboard conditions. The system must present minimal impact on the UAV so as to preserve its performance and promote portability and interchangeability between different UAVs. The system must also be capable of long-lived operation in the Navy unique environment, including requirements for shock and vibration, and the interfaces must be capable for use throughout the Navy Fleet.

PHASE I: Develop a low-cost, low-manning ship/UAV Recovery, Securing and Handling interface concept including drawings, descriptive narrative and operating sequence description, weight breakdown and system cost estimates (acquisition and lifecycle) and manning validation.

PHASE II: Design and fabricate a prototype of the system developed in Phase I. Demonstrate the operation of the system in recovering, securing and handling a simulated UAV in land-based testing. Demonstrate operation in a variety of scenarios fully simulating shipboard conditions. Determine system weights, acquisition and lifecycle cost estimates, ship and UAV impacts, and operational parameters.

PHASE III: Develop transition plans and demonstrate the commercial and shipboard uses of the recovery, security and handling interface. Conduct shipboard feasibility testing to evaluate performance in the Navy environment and develop full acquisition and lifecycle cost estimates. Provide detail drawings and specifications.

COMMERCIAL POTENTIAL: Any commercial ships or off-shore platforms, employing vertical takeoff/landing UAVs or small helicopters could use such a system for similar purposes as those of the Navy.

REFERENCES:

1. Installation Design Requirements (IDR) for Vertical Take-off and Landing Tactical Unmanned Aerial Vehicle VTUAV, 29 September 2000
2. IL-S-8512 -- General specification for aircraft carrier deck support equipment
3. SAE AS-8090 -- Mobility specification

KEYWORDS: UAV, Landing, Arresting, Harpoon, Aircraft Handling

N02-031 TITLE: Automated Shipboard Provisions and Material Transfer System

TECHNOLOGY AREAS: Materials/Processes, Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: PEO Surface Strike (DD-21)

OBJECTIVE: Develop and demonstrate automated provisions/material transfer technologies that will significantly reduce shipboard manning and outfitting requirements through automated operation (deploy and stow), handling—both onto ship and with ship, product identification and tracking, and improved cycle time(s) while improving system safety, reducing ship signature, and supporting all phases of shipboard operations.

DESCRIPTION: Transfer of provisions and food service material onto and within US Navy ships are manpower-intensive operations. The shipboard processes employed are almost entirely manual with minimal modern equipment and little automation. Material is landed aboard ship from a variety of methods (at-sea Underway Replenishment (UNREP), pier-side, at-anchor) all employing different methods and equipment. Once aboard ship, the material unit load is inefficiently transferred to multiple stowage locations either manually or by breaking the standard unit load into smaller units to leverage existing shipboard material handling systems. Operator safety is problematic for deploying current provisions/material transfer systems.

Requested is an integrated system(s) addressing provisions/material transfer to eliminate the shipboard workload, signature impact, and equipment currently associated with these operations. The Provisions/Material Transfer System (PTS) would integrate and automate the process of deploying, operating, and stowing provisions/material. PTS would facilitate all methods of inter-ship provisions/material transfer, including UNREP, and would provide the foundation for intra-ship provisions/material handling, including determination of product destination and subsequent routing. PTS would also support inventory management/tracking through integration with proposed ship-wide monitoring systems. The PTS will include computer-controlled sensors and operating mechanisms able to withstand shipboard motions and environmental conditions. Legacy shipboard transfer components are not currently integrated, and current ship design practices do not facilitate upgrade or modernization except in the most rudimentary manner. The development of a re-engineered transfer system and the implementation of innovative automation technologies to minimize the manpower requirements and signature impacts on Navy ships are required. These new methods must employ automation and mechanical aids designed for operation aboard Navy ships in a reduced/optimally-manned environment and must reduce overall ship system requirements.

PHASE I: Develop an automated PTS concept for Navy surface combatants for provisions/material transfer functions to reduce manning requirements and reduce current outfitting and area/volume impacts. Include shipboard provisions/material handling and routing as an adjunct function of PTS beyond simply transferring material to ship. Identify the resultant manning reduction, lifecycle costs and shipboard impacts and performance in the Navy unique environment. Design conceptual prototypes and demonstrate key equipment and processes. Identify required equipment, concept of operations, architectures, and interfaces including HSI, ship-machine and with existing and planned logistical support communities.

PHASE II: Prototype the automated PTS concept as determined in Phase I. Demonstrate connectivity with ongoing and proposed future efforts for ship-wide monitoring systems. Develop a concept to expand PTS to include demonstrating (land-based) the operation of processes and individual items including defining maintenance procedures and projecting lifecycle costs for all Navy shipboard operational scenarios. Define interface boundaries and conditions for new system processes and equipment to address likely interfaces with legacy Navy systems such as shore-side/underway logistics systems, inventory management/accounting tools, and ship general arrangements. Evaluate performance in the Navy unique environment including shock and vibration requirements.

PHASE III: Demonstrate the automated PTS system aboard a US Navy ship operated by Navy personnel. Document

manpower reduction, lifecycle cost projections, maintenance requirements, impacts and interfaces with other ship systems and the existing and planned logistical support communities, and performance in the Navy unique environment. Develop a plan to transition the PTS system concept on US Navy platforms.

COMMERCIAL POTENTIAL: Cruise ships, cargo ships, tankers, and workboats in the commercial sector could benefit from the incorporation of automated, integrated provisions/material transfer technologies and approaches, as could MSC and USCG ships. The ability to unify provisions/material handling equipment for operation exterior and interior to the ship has broad commercial application; as does integration of material handling and product identification and destination tracking.

REFERENCES:
1. "NAVSUP Advanced Food Study aboard USS McFaul", Naval Supply Systems Command, Mechanicsburg, PA, September, 1999.
2. "Modular Reefer Box Technology Demonstrator", Naval Sea Systems Command, Affordability Through Commonality Program (PMS 512), Arlington, VA, December, 1997.
3. "Co-Located Galley Life Cycle Cost Analysis for the Affordability Through Commonality Program," August 1997,prepared by Naval Sea Systems Command, PMS 512 under Contract # N00024-92-C-4215: TI 6A016.
4. "Commercial Applications in Aircraft Carriers", Naval Sea Systems Command, PMS 312, Arlington, VA, March, 1999, prepared by MSCL Incorporated under Contract # N00024-95-C-4180: TIs 7J201, 8J008, 8J020, and 8J108.

KEYWORDS: Automation, Provisions/Material Handling, Food Service, Material Transfer, Product Identification

N02-032 TITLE: Modeling Tool for Design, Manning, and Training of Shipboard Aircraft Operations

TECHNOLOGY AREAS: Materials/Processes, Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: PEO Surface Strike (DD-21)

OBJECTIVE: Develop and demonstrate a computer-based tool for modeling shipboard aircraft operations for estimating the manning requirements, analyzing safety requirements, and providing crew training. This tool will allow the evaluation of alternative system designs and operating procedures during the ship design process. The built-in customizable data objects will model the launch and recovery of helicopters, UAVs, and VTOLs from surface combatants and auxiliary ships in a combat environment with varying weather and sea states. The tool will provide on-screen animation of the launch and recovery processes. Replays provided by a video recording capability will assist system designers to optimize the aviation portion of the ship's design using human system integration (HSI) techniques. When the design, manning, and operational procedures are set, the resulting animations will in turn be used for crew training. The tool will allow the capture and analysis of data needed for parametric analyses during the shipboard avionics system design and for assessing a trainee's performance during training sessions. Finally, the tool will be designed in a modular fashion easily facilitating changes due to the modifications and additions of functionality as technology and missions change. In view of the rapidly increasing role of aircraft launched from ships engaged in littoral warfare, growing demands for manning reductions aboard future naval combatants, and an equally rapidly decreasing tolerance for exposing crew to injury, a tool with the capabilities described above is vital.

DESCRIPTION: The key requirement in designing the aviation facilities is to complete all the tradeoff studies that are associated with the aviation system design before the ship's size, arrangement, and manning levels are frozen. The effects of changes in aviation facility design on ship's size, arrangement, manning, mission worthiness, and situational awareness produce significant cost impacts during later stages in ship design. Tradeoff studies for aviation system and manning levels are quite complex. The hangar, pad, aircraft handling gear, adjacent deckhouse structure, and masts have to be quickly arranged and modified during design cycles and parametric studies. Ship motion, atmospheric conditions, and visibility have to be emulated. Aircraft control systems must be modeled, and takeoffs and landings need to be simulated. Own-ship and enemy action must be emulated to represent the combat environment. And finally, models of damage, equipment malfunction, and operator casualties must represent the applicable abnormal operating conditions. All these have a direct impact on manning levels. With the optimally manned ships required for the future fleet,

understanding these manning and system impacts early in the acquisition process is vital.

This tool will provide scientific computation, graphics, and simulation that will provide the following capabilities:

* On-screen modeling and editing of ship's geometry in the aviation area
Situational awareness displays using views of the moving ship and aircraft from selected angles to detect interference in aircraft operation by ship's structure
* Situational awareness effects through the simulation of offensive and defensive activities in which the ship may be engaged during aircraft launch or recovery
* Incorporating the modeling of animated human characteristics into the analyses
* Algorithms for computing ship motions in specified sea-states
* Simulation of aircraft's ground handling operation carried out by a given set of handling gear and crew
* Simulation of operator control on aircraft's power plant, landing gear, and control surfaces
* Computation of aircraft behavior during takeoff, flight, and landing under normal operating conditions and under specified damaged and malfunctioning equipment

The tool will integrate these capabilities into a seamless system for (a) rapidly creating and editing shipboard avionics models, specifying the weather and visibility as well as combat environments, scripting events and defining the logic (tactical doctrine); (b) interactively controlling selected aspects of simulation; (c) capturing the data and video of the aircraft launch and recovery operations; and (d) collecting and organizing results from multiple replications to estimate the effectiveness (probability of success) of a design solution for given manning policies and operating procedures.

To use this tool in a training environment, the hardware will be network compatible allowing the instructors and trainees (the pilot, flight controller, and ground crew) effective interaction.

PHASE I: Provide proof of concept through the animation of landing and takeoff operations on a ship; demonstrate the ability to create and modify ship's geometry required in this simulation; show that the model development and execution processes can be packaged to be sufficiently compact for use during concept design.

PHASE II: Complete the design of the modeling tool. Run test cases to validate algorithms and incorporate feedback results. Develop a detailed design document for the tool for potential transition to Phase III. Finalize the database design. Build prototype database.

PHASE III: Produce and market the final system design. Develop design for implementation into other shipboard teams and other ship classes (CVN, LPD-17, etc.). Assist users in adopting the tool in their design processes, and later for the crew-training phase.

COMMERCIAL POTENTIAL: This will have applications to military, government, and private sector organizations where air operations are involved. Helicopters are used extensively in offshore drilling operations. The problems in modeling platform motion, structural interferences in the air space that surrounds the landing pad, equipment failures, and fires are sufficiently similar so that they can be handled by customizing the library objects assembled for use in naval surface ship design and crew training. Air operations from Coast Guard ships performing search and rescue missions come even closer to the operations from naval ships and would be candidates for this tool.

KEYWORDS: Naval Aviation, Combat Ship Design, Shipboard Aviation, Manpower, Human System Integration, Training, Health and Safety.

N02-033 TITLE: Automated Handling Systems for Launch and Recovery of Offboard Vehicles

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: PEO Surface Strike (DD-21)

OBJECTIVE: Develop a lightweight, low cost, fully automated handling system for launch and recovery of offboard vehicles, which can be fitted to existing ships or designed into new classes of ship.

DESCRIPTION: As the number of capital ships decreases we will be employing an ever increasing number of unmanned systems to leverage the capabilities of the ship while maintaining distance from the threat. Future ships such as DD-21 will operate with a crew of about 95. Therefore, many functions will be automated. DDG-91 is currently being designed to carry the Remote Minehunting System (RMS). Part of the system is an automated launch and recovery system. However, significant hull form modifications are being made to accommodate this system. Fleet standard DDGs do not have a system similar to RMS. Should the Navy decide to add such a capability to these ships the L&R would likely be very manpower intensive. However, if a modular automated system can be developed and added as a ship alteration, the introduction of unmanned offboard systems can be accelerated to the fleet. The system is required to perform self-tests and integrate with offboard vehicle self-test system to indicate that all systems are ready prior to vehicle launch. Upon activation the system must deliver the vehicle over the side of the ship into the water and release it without interfering with other equipment or ongoing operations. When the offboard vehicle returns, the launch and recovery system should communicate with the vehicle, assist it with the required close proximity approach, secure the vehicle, and bring it aboard the ship. The only requirement to be placed on the ship is maintaining a steady course and speed.

PHASE I: Develop a conceptual design of the system for use with an existing 7 meter Rigid Hull Inflatable Boat (RHIB) with estimates of the weight, cost and ship alteration requirements. Select at least one ship for which the location and concept of operations are defined.

PHASE II: Develop a detailed design, produce a working scale model, specify the system components and conduct a technology survey to define COTS components available for use during production. Test the scale model at an appropriate facility. Revise the estimates of weight, cost and ship alteration requirements developed during phase I.

PHASE III: Fabricate a full scale system using a GFE 7 meter RHIB, demonstrate automated functionality from a dock, and assist in the installation aboard a ship to be selected by the Navy. Participate in testing at sea.

COMMERCIAL POTENTIAL: Automated handling systems are in great demand throughout industry; the oil exploration industry in particular employs a large number of off board vehicles and would have a use for such a system.

KEYWORDS: Automated Handling, Automation, Offboard Vehicles, Unmanned Vehicles, Launch and Recovery, Handling Systems

N02-034 TITLE: Scalability and Reusability Methods for Intelligent Tutors and Job Performance Aids for the Maintenance of Reduced Manning Ships

TECHNOLOGY AREAS: Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: PEO Surface Strike (DD-21)

OBJECTIVE: The objective of this effort is to develop and demonstrate scalability and reusability methods that allow Intelligent Tutors and Job Performance Aids (JPAs) the ability to expand across system boundaries combining on-demand training, with the simultaneous repair of specific maintenance tasks. This will reduce the workload of maintenance personnel onboard future reduced-manning ships, as well as reduce maintenance costs due to incorrectly diagnosed and repaired ship systems.

DESCRIPTION: Future Navy ships will be operated and maintained by significantly fewer sailors. Increasing use of automation, along with improvements in system reliability are behind this trend. One of the negative aspects of this, is increased workload pressure due to the increase in the number and variety of systems assigned to the remaining maintainers. At the same time, as more reliable systems require less regular maintenance, skill erosion occurs. When something finally does go wrong, the maintainer faces a wider variety of maintenance problems with degraded skills, resulting in increased maintenance costs due to incorrect diagnosis and repair.

Research and development efforts are required to expand the utility of advanced distributed learning (ADL) systems and maintenance training aids. These aids must work from the component level to larger portions of the overall system, up to and beyond the platform level. This proposal will investigate the scalability and reusability issues involved with the expansion of the component level ADL aids into these larger system arenas. It will provide methodologies to use, and a test bed to demonstrate the effectiveness of these methodologies.

The proposed methodologies and test bed training device will effectively and efficiently combine training with maintenance in an on-demand system that will allow the maintenance personnel on optimally manned ships to function effectively and efficiently under the new constraints these ships impose. Methodology studies will focus on identifying and overcoming the boundary issues related to expanding system boundaries. System boundaries can relate to system size (e.g. component or platform), design cycle location (e.g. legacy or new design), or system types (e.g. mechanical vs. electrical). The computer-based test bed will consist of three parts, 1) a portable multi-modal, hypermedia computer system that provides hands-free virtual displays, 2) interactive electronic technical manual, and 3) an intelligent tutoring system that keeps both information on individual maintainers as well as the ship's equipment maintenance schedules, requirements, and status. Human Systems Integration (HSI) processes knit these together to produce an intelligent device that is scalable to any size system, and can provide on-demand training, learning, and repair simultaneously without regard to the level of expertise of the user.

The outcome of this R&D initiative is simultaneous maintenance and training requiring significantly fewer onboard maintenance skills, and therefore, a dramatic reduction in maintenance manning, substantial improvements in maintenance effectiveness, and reduced costs associated with incorrectly diagnosed repair and maintenance actions.

PHASE I: Define the scalability and reusability requirements for intelligent tutors and JPAs used on optimally manned ships. Review the current state of ADL, JPA, and intelligent tutor technology with respect to the above requirements. Define the test bed device software and user-computer interface (UCI) requirements, and identify the host application under which the device will run. Develop the concept for the architecture for the maintenance data to be assessed. Select a sample set of maintenance activities targeting a selected large scale system, such as the propulsion plant, and conduct a training and maintenance needs analysis to identify required skills, knowledge and abilities, and identify how the system will provide these skills, knowledge and abilities. Develop a model of user-tool interactions and transactions in representative tool use situations. Develop porting strategies that are scalable and reusable. Develop and demonstrate a conceptual design for the training/maintenance device.

PHASE II: Develop the prototype of the device focusing on a selected large-scale system, such as the propulsion plant, and beta test this prototype using input from representative end users. Modify the software accordingly. Define a set of representative systems, missions, scenarios and functions and populate the training and d maintenance procedures, descriptive materials, and tutorial database. Develop the on-line help resource. Produce user guide documents.

PHASE III: Market the final system to suitable Navy agencies and contractors, and potential commercial users, and promote the use of the on-demand maintenance-training device for other shipboard teams and ship classes (CVN; LPD-17, etc).

COMMERCIAL POTENTIAL: This system will have applications to military, government, and private sector organizations where maintenance requirements must be satisfied by a limited number of maintenance personnel working across varying size and types of systems. It will reduce the costs associated with incorrectly diagnosed repair and maintenance actions. These costs are big dollar drivers in maintenance costs.

REFERENCES:
1. Chief of Naval Operations (N86) Operational Requirements Document for Land Attack Destroyer (DD-21) dated 3 December 1996
2. Oser, R. L., Cannon-Bowers, J. A., Salas, E., Dwyer, D. (1999). Enhancing Human Performance in Technology Rich Environments: Guidelines for Scenario-Based Training. In E. Salas (Ed.), Human/Technology Interaction in Complex Systems, (pp. 175-202).
3. Ames, T. J. and Baker, C. C. (1990). Hypermedia and Intelligent Tutoring Applications in a Missions Operations Environment. Professional paper presented at the NASA/Johnson Space Flight Center Symposium on Hypermedia, Houston Texas.
4. National Advanced Distributed Learning Initiative website: www.adlnet.org

KEYWORDS: Just-in-Time Training, Maintenance Training, Tele-Maintenance, Training, Skill Acquisition, Job Performance Aids, Intelligent Tutors, Advanced Distributed Learning

N02-035 TITLE: Integrated Ship Environmental Management System (IS-EMS)

TECHNOLOGY AREAS: Chemical/Bio Defense, Information Systems, Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: PEO Surface Strike (DD-21)

OBJECTIVE: Develop and demonstrate an integrated ship environmental management system (EMS) to coordinate and manage ship environmental issues, certifications and responsibilities, facilitate environmental compliance and decrease ship environmental workload.

DESCRIPTION: Navy ships are subject to many international, federal and local environmental requirements. Despite Navy efforts to disseminate environmental policy and install environmentally compliant technology on ships, inspections have documented instances of environmental non-compliance, inoperative equipment, and ship unfamiliarity with requirements. Ships have voiced frustration regarding the burden and nuisance of environmental equipment and programs. Lifecycle configuration management has been complex due to changing requirements and systems. Many organizations have implemented environmental management systems (EMS's) in response to similar issues. Those organizations include large land-based industries, shipping companies, cruise lines, federal and state governments, and other navies.

An EMS is a single system or a collection of management systems designed to assist an organization in maintaining control over and configuration management of the environmental performance of its activities, products, and services. The intended result of an EMS implementation is to improve the environmental performance of the organization on a continual basis through carefully designed management practices at all levels of operation. The Integrated Ship Environmental Management System (IS-EMS) would be a life-cycle approach to environmental management that facilitates information exchange and therefore increases awareness and the ability to prioritize environmental issues facing a ship. The IS-EMS would provide ships with a standardized software environment to assist in complying with all environmental requirements as outlined in Navy environmental policy documents. It would provide ships with a management tool for identifying, delegating, and tracking shipboard environmental workload; measuring environmental performance; producing reports and preparing for inspections; and communicating Fleet experience, problems, and recommendations back to the shore-based supporting infrastructure. It would collect information from ships to assist Headquarters, Type Commands, and Program Offices with risk analysis, planning, policymaking, and configuration management. The ship design community could use information collected from ships to facilitate the improved design of environmental capabilities in future ships and improved total ship design. It would communicate shore-based responses back to at-sea ships. It would integrate with existing and databases and computer systems as available and necessary. It would operate with DD 21 planned shipboard computer systems. The net result should be streamlined, efficient, environmental management throughout the ship lifecycle.

PHASE I: Develop a detailed IS-EMS concept for a Navy surface combatant, including a functional requirements document for the ship software and for the website with which it will interact. Identify system users (both ship and

shoreside), a concept of operations, and required equipment, software, and interfaces. Include relevant data to be collected from the ship, and how the information will be processed and transferred to the larger naval community. Identify ship software acquisition and lifecycle costs and document how it will change the shipboard working environment and Sailor environmental burden.

PHASE II: Analyze and demonstrate feasibility of a prototype IS-EMS system, including a ship software package, a website, and necessary documentation for the various IS-EMS interactions and protocols. Project shipboard workload impacts, maintenance requirements, performance of the system, and life cycle cost estimates

PHASE III: Develop transition plans and demonstrate the commercial and shipboard use of an IS-EMS. Demonstrate the IS-EMS aboard a Navy ship operated by Navy personnel. Evaluate performance in the Navy environment, including documentation of shipboard workload impacts, shipboard perception, maintenance requirements, and performance of the system. Develop acquisition and lifecycle cost estimates.

COMMERCIAL POTENTIAL: The maritime industry is required to implement Safety Management Systems by the International Safety Management Code. These systems must include pollution prevention management, and are very similar to environmental management systems. The maritime industry could benefit from a more integrated, standardized, interactive, and "non-paper-based" system. The maritime industry is not transferring knowledge gained from operating environmental systems via their safety management systems, and could also benefit from that IS-EMS capability.

REFERENCES:
1. Executive Order 13148, Greening the Government through Leadership in Environmental Management.
2. SECNAVINST 5090.8, Policy for Environmental Protection, Natural Resources, and Cultural Resources Programs.
3. OPNAVINST 5090.1B CH-2, Environmental and Natural Resources Program Manual.
4. ANSI/ISO 14001-1996, Environmental Management System – Specification with Guidance for Use.

KEYWORDS: Environmental Management System, EMS, Life Cycle, Environmental Compliance, Data Collection, Problem Identification

N02-036 TITLE: Engineering Control Human Performance Tool to Enhance Situational Awareness

TECHNOLOGY AREAS: Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: PEO Surface Strike (DD-21)

OBJECTIVE: The objective of this effort is to develop and demonstrate an automated tool that will enhance the ability of human systems integration (HSI) professionals and systems engineers to identify shipboard engineering operational tasks in which a high potential for human overload and error can be expected, and to develop solutions in the form of prototype displays that will provide needed information and situational awareness while reducing cognitive workload.

DESCRIPTION: The increased use of automated sensing and autonomous machinery control in Navy ships is expected to result in reduced human operator workload and thereby reducing manning. Task workload analyses conducted using the DDG 51 class destroyer as a comparison baseline have shown that, on average, about 17.6 man-hours of workload are required during a four-hour watch. This includes routine operation and monitoring of machinery systems with no major casualties. Some of the current workload/manpower reduction technologies and potential impacts are Integrated Condition Assessment System (ICAS) and the Reduced Ship's Crew by Virtual Presence (RSVP) initiatives. These systems will largely eliminate the need for hourly rounds by roving equipment monitors and the sounding and security monitor. The Integrated Power System (IPS) may considerably simplify turbine and generator operation. Automated fuel sampling and analysis systems should result in greatly reduced fuel management workload.

Many functions that are currently workload intensive can be automated with a corresponding reduction in manpower under normal operating conditions by means of the automation and technology initiatives listed above. However, when

and where operator intervention is required has not been addressed. This leaves a large gap of knowledge surrounding the question: "How will the relevant data be selected and displayed and how will the operator use these data to monitor, diagnose, and correct off-nominal machinery and shipboard space events and conditions?" The automated data collection systems listed above will be able to transmit large amounts of information to the engineering control personnel and this will probably be sufficient to overload the operator. What is required is a comprehensive analysis of operator task requirements, workload and error modes, and information display concepts during performance of diagnostic and corrective activities to give the operator better situational awareness of engineering control. Machinery and engineering space contingency events may not require workload/manpower intensive corrective maintenance actions, especially if design approaches use component redundancy to defer maintenance until after a mission is completed. Nevertheless, diagnostic and decision making tasks will be required prior to these actions and the cognitive demands of these tasks may be considerably greater than the demands of the final corrective action.

The workload levels and human error potential characteristic of diagnostic tasks may be significantly increased in reduced manpower environments because the operators will not have been involved in monitoring and evaluating the engineering plant performance over a period of watchstanding as they do in existing ships. This will place a burden on effective filtering, fusing, integration, and display of machinery status to operators and on algorithms for decision support and system response simulation. In effect, engineering watchstanders will cease to be equipment operators and will become casualty managers. This SBIR effort will address the task workload and performance of tasks central to data monitoring, decision making, and casualty diagnosis on the part of engineering department operators and maintainers in reduced manpower environments. The necessary tasks will be driven by off-nominal events associated with future engineering plant machinery and automated data collection systems. Task analytical methods will be used to identify the universe of operator/maintainer functions and tasks in a highly automated reduced manpower environment. A function/task database will be developed containing an inventory of future ship engineering tasks in areas including data collection, data filtering, data fusion, machinery trend monitoring, hypothesis testing, symptom-based diagnosis, decision making, and action selection with regard to casualty response. Task characteristics will include information requirements, decision requirements, action requirements, task duration, operator skill/knowledge requirements, operator error modes, and other appropriate descriptors. Discrete event task network simulation methods and workload analysis methods will be used to exercise networks of tasks under various off-nominal and contingency event scenarios. System engineers and human systems integration (HSI) specialists, in developing appropriate workload/manning concepts, in evaluating these concepts, and in performing detail design of operator/maintainer tasks, will use these data and human-machine interfaces in designing optimally manned ships.

The result of this effort will be an enhanced ability on the part of HSI professionals and system engineers to identify tasks in which a high potential for human overload and error can be expected in shipboard operations, and to develop prototypes of displays to provide needed information with reduced cognitive workload for better situational awareness. Reduction of casualty management workload and human error likelihood will then be achieved through human machine interface design, training, reorganization of jobs and tasks, and restructuring of the information and knowledge provided to the human operators.

PHASE I: Define the tool software and user-computer interface (UCI) requirements and identify the host application under which the tool will run. Define example scenarios, conditions, functions, tasks, and error modes for a representative ship and its representative engineering control systems. Develop a model of human task performance with indications of workload and error modes and implications. Develop a model of user-tool interactions and transactions in representative tool use situations. Develop and demonstrate a conceptual design for the tool.

PHASE II: Develop the prototype of the software and beta test this using input from representative end users. Modify the software accordingly. Define a set of representative systems, missions, scenarios and functions and populate the workload assessment and error modes and effects databases. Produce user guide documents.

PHASE III: Make the software available to suitable Navy agencies and contractors, and potential commercial users, and promote the use of the engineering control workload reduction tool in concept evaluation efforts for other shipboard teams and ship classes.

COMMERCIAL POTENTIAL: This will have applications to military, government and private sector organizations

where performance of humans using complex human-computer interfaces in reduced manning environments would benefit from application of this tool and where improved situational awareness of engineering control is needed.

REFERENCES:

1. Chief of Naval Operations (N86) Operational Requirements Document for Land Attack Destroyer (DD-21) dated 3 December 1996.
2. Oser, R. L., Cannon-Bowers, J. A., Salas, E., Dwyer, D. (1999). Enhancing Human Performance in Technology Rich Environments: Guidelines for Scenario-Based Training. In E. Salas (Ed.), Human/Technology Interaction in Complex Systems, (pp. 175-202).

KEYWORDS: Usability, Human Systems Integration, Human-Computer Interface, Workload, Decision Support Systems

N02-037 TITLE: <u>Low-Cost Automatic Shipboard Wireless Configuration Management</u>

TECHNOLOGY AREAS: Information Systems, Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: PEO Surface Strike (DD-21)

OBJECTIVE: Develop an integrated approach for automatic configuration management of shipboard physical systems and related information by exploiting shipboard wireless location area networks (WLAN). This innovative approach will facilitate a reduction in total ownership cost by reducing shipboard workload and enable simplified technology and other shipboard upgrades due to streamlined configuration management.

DESCRIPTION: Commercial applications of wireless radio frequency (RF) LANs have matured extensively over the past 3 years. Navy wireless information technology (IT) systems are being developed for increased shipboard information gathering for logistical, personnel, and maintenance-related systems. Shipboard wireless systems offer adaptability for COTS technology refresh over long shipboard lifecycles and are particularly applicable for collecting system data/information from multiple remotely located systems and for mobile access to computer networks. Wireless LAN installations can promote lifecycle cost savings over conventional "wired" networks through simplified reconfiguration in response to new technology or mission/requirement changes.

With increased used of Commercial Off-the-shelf (COTS) systems on Navy ships and the attendant low COTS lifecycles compared to ship lifecycles, frequent shipboard upgrades are projected in response to technology refresh and technology insertion needs. Such upgrades present challenges for maintaining configuration management over Navy ship systems.

The growing number of ships with a wireless LAN presents an opportunity to simplify the configuration management of ship systems. An automatic shipboard wireless configuration management system exploits this new capability by use of small, low-cost RF tags within the WLAN. Such wireless configuration management (WCM) tags, provided with different ship systems as they are installed on ship, would contain all necessary information sufficient for the ship to exercise configuration management. These WCM tags would either point to web-based information that would be accessible for shipboard retrieval or contain such information organically. WCM Tags would be upgradeable for new or revised features via low-cost wireless standard interfaces. WCM Tags would enable access to all necessary information for shipboard operation and maintenance including necessary technical manuals, integrated logistics documents, training manuals, drawings, and other necessary documents. By supplying such information in a wireless fashion, configuration management is simplified as the shipboard WLAN automatically registers new systems as installed (or removed). There is no need for a human action to input data or scan system identification numbers. Thus, increased shipboard adaptability is enabled.

Particular challenges in the shipboard environment are critical to overcome in realizing this approach. WCM Tags must passively communicate with the shipboard WLAN via industry standard Open Systems Architecture interfaces which may change over time. WCM Tags must operate in a Naval environment with extremes of temperature, humidity, shock, vibration, smoke, sea spray, and electromagnetic interference for over 30 years. Tags must be small, operate

passively (un-powered) and require no wiring to other shipboard systems, and must be sufficiently inexpensive to permit distributed use for ship systems. Ship WLANs must be able to distinguish between and track thousands of different tags over the entire ship lifecycle. The payoff of this approach is in the reduced lifecycle cost due to simplified configuration management of ship systems, thus automated for use on reduced/optimally-manned ships.

PHASE I: Develop approach and demonstrate feasibility of automatic shipboard wireless configuration management (WCM) tags to operate within a wireless ship LAN. Conduct feasibility testing to evaluate performance in the Navy environment and develop acquisition and lifecycle cost estimates.

PHASE II: Design and demonstrate shipboard an automatic shipboard wireless configuration management system using existing wireless shipboard LANs and WCM tags. Conduct feasibility testing to evaluate performance in the Navy environment and develop acquisition and lifecycle cost estimates. Conduct testing to simulate the 30-year necessary lifecycle of WCM tags aboard ship.

PHASE III: Develop transition plans and demonstrate the commercial and shipboard use of an automatic shipboard wireless configuration management system with WCM tags. Develop schemes to reduce the production costs of WCM tags. Conduct feasibility testing to evaluate performance in the Navy environment and develop acquisition and lifecycle cost estimates. Conduct testing to simulate the 30-year necessary lifecycle of WCM tags aboard ship.

COMMERCIAL POTENTIAL: Commercial interest in wireless communications represents one of the fastest-growing sectors in the information technology field. RF passive, semi-passive and active tags are being used in a growing number of applications. Configuration management represents a challenge for the commercial sector as well as the military, with increased technology refresh due to decreased system lifecycles. An automatic shipboard wireless configuration management system using WCM tags would find utility in any venture/system with a wireless LAN such as a building for tracking high value equipment, an off-shore oil platform tracking parts and components, an commercial aircraft tracking components and their maintenance records.

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3. USS The Sullivans Wearable PC and Wireless LAN Electromagnetic Interference and Threat Analysis Test Report, 15 October 1998, PEO Theater Surface Combatants, PMS-400F7.

KEYWORDS: Configuration Management, Wireless Technology, LAN, WLAN, Cost Reduction, Affordable, Upgrade, Maintenance

N02-038 TITLE: Advanced Digital Array Radar (DAR) Sensor Systems/Subsystems

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT III: PMS 452/426 Advanced Digital Array Radar (DAR) Sensor Systems

OBJECTIVE: Advanced Digital Array Radar (DAR) sensor systems, components, sub-components are needed to support technology refresh by Navy radar programs. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

DESCRIPTION: DAR sensors and their associated systems/sub-systems function as the primary detection mechanism for ballistic missile and air breathing threat defense applications, providing early warning of attack, target detection/classification/identification, target tracking, and kill determination. New and innovative approaches to these

requirements using unconventional and innovative techniques are encouraged across a broad band of the RF electromagnetic spectrum. Active, and interactive techniques for discriminating targets from backgrounds, debris, decoys, chaff, electronic countermeasures, and other penetration aids are specifically sought. Sensor-related device technology is also needed. Examples of some of the technology specific areas are: T/R module and antenna arrays, signal distribution, photonic interconnects, time delay units, open system standards, Electronics Counter-Countermeasures/ Adaptive jammer cancellation, low phase noise sources, radar timing and control, sub-array beam forming, efficient radiating elements, energy storage. Entirely new and high-risk approaches are also sought.

PHASE I: Demonstrate that a new and innovative approach can meet any of the broad needs discussed in this topic for future radar systems consideration.

PHASE II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

PHASE III: Develop pre-production and production components and sub-systems for integration into Navy surface combatants.

COMMERCIAL POTENTIAL: These technologies could be applied in many RF applications such as the cell phone industry, commercial airport radar systems, and automotive industry.

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KEYWORDS: Radar, T/R Module, HPA, Wide Bandgap, Wide Bandwidth, Thermal Management

N02-039 TITLE: Multiple Function Distributed Test and Analysis Tool

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II: PMS 400B - Aegis Weapons Systems

OBJECTIVE: Enable engineering and technical personnel to collect and analyze complex electronic system characteristics for performance trending, remote monitoring, error and workload reduction. This system, if developed, will allow more comprehensive and thorough radar system grooming and testing with less support from the AEGIS In-Service Engineering Agent. This will allow the Navy to improve performance of fielded systems at current or reduced infra-structure cost levels.

DESCRIPTION: Information and data acquisition technologies have been demonstrated as useful tools in the acquisition, storage, transmission and analysis of complex electronic systems. Statistical analysis tools that utilize data acquired during critical or complex procedures may be useful to support decision-making processes and reducing analysis time and work effort. The integration of these tools would require the research and development of heuristic or neural models that accurately reflect the behaviors of the system under test in varying conditions. These software models can be used to validate optimum characteristics of the system under test with current characteristics. This would result in alignments and analyses with tolerances that cannot be consistently achieved with manual processes, which, in turn, would improve system performance and reduce down time. Computer control of the test instrument and validation of the results would significantly reduce or eliminate errors caused by incorrect settings or misinterpretation. The acquired data would be in a form that is easily shared among collaborating technical personnel at diverse locations, reducing support

costs. Finally, the database model could integrate multiform technical material, enhancing technical training.

PHASE I: Explore innovative technology ideas and develop a feasible concept for a multiple function distributed analysis tool using a candidate system. The concept should incorporate: record functions to archive data necessary for trending; software models to trend and analyze performance changes and characteristics; a "pass to proceed" function for step oriented test procedures; instrument controls for operation in a test development and test execution mode; technical data, displayed relative to the test procedure, system, unit and component under test; and a remote capability to support collaboration between technical and engineering personnel in divergent locations.

PHASE II: Design, fabricate and demonstrate a prototype proof of concept unit and remote monitoring station based on Phase I design objectives. The proof of concept shall demonstrate a significant reduction in "front to back" alignment time, a savings in test equipment and support costs, and a reduction in maintenance and training time for engineering and technical personnel. The test instruments used should be non-intrusive and have no additional affect on the current system operations or operating systems. The Phase II effort shall validate the proof of concept, define hardware, software and firmware for a Phase III effort.

PHASE III: Develop production system for Navy radar application building on the Phase II the prototype. Transition to commercial markets and non-SBIR funded status through the sale of derivative proof of concept units to private corporations and government agencies who own, operate or maintain, cellular or personal communication systems, radar or radio transponder systems, cable and broadcast television and radio networks, or medical diagnostic and imaging systems, as a single integrated systems analysis tool.

COMMERCIAL POTENTIAL: Private sector costs for highly trained personnel, expensive single purpose test equipment, on-site monitoring and non faulted component replacements for complex electronics systems are not unlike that of the government. Providing a tool that can provide accurate and reliable trend analysis for systems that are gradually failing, allow for remote monitoring of critical elements and reduce alignment time will reduce support costs. Also reduced will be the cost of travel and system non-availability. System down time for commercial ventures is costly and non-productive, the decrease in down time will be a net increase in productivity.

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3. The Use of Microcomputers to Improve Army Ground Vehicle Readiness, SALTER, R. G. R-2495-ARPA, Rand Group, 1700 Main Street Santa Monica, CA 90407-2138, 1-800-462-6420
4. "Knowledge based diagnosis: Dealing with fault modes and temporal constraints", Acosta, G., IECON Proceedings (Industrial Electronics Conference), Vol. 2, 1994, p. 1419-1424.
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6. Predictive Maintenance and Logistics (PML) (P-7104) R. G. Salter. 1985. Available From Rand Group, 1700 Main Street Santa Monica, CA 90407-2138, 1-800-462-6420

KEYWORDS: Automation, Model, Test Equipment, Analysis, Human, Workload

N02-040 TITLE: Multi-Function Displays for Warfighter Consolidation

TECHNOLOGY AREAS: Information Systems, Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT 1C: PMS400D -DDG 51

OBJECTIVE: Develop a display management architecture coupled with a display to allow multiple functional roles to be managed and executed through a single display.

DESCRIPTION: The human interface too command and control of the battlespace is implemented through and depends upon display systems. The ability of these systems to effectively present rapidly convey information ranging from equipment and weapons status information to sensor detections to a synthesized full battlespace representation dramatically impacts combat effectiveness. With the budgetary and crew size reductions and the increasing pace and complexity of the battle space it is essential to find ways to manage and execute multiple warfare functions through a single display. The ability to do this depends on managing the information displayed at any one time, presenting the information in a fashion that most quickly and effectively conveys knowledge to the user, and achieving maximum contrast, clarity, and information density on the display without loss of readability.

Information and knowledge management provide potential approaches to the first part of this problem. Use of knowledge base concepts as organizational underpinnings for software agents monitoring user activities may provide the structure for a system to perceive current user needs and manage the presentation of information available from all sources. The manager would also need to balance the presentation of information for the current action with information about other competing functions. Genetic algorithms, fuzzy logic, semantic networks, and other algorithmic tools may support the depth and sophistication of information processing required. Information display presents a second challenge. The "best" display is the one that most quickly and effectively provides the user with the knowledge needed to understand the situation and execute the best course of action. The use of 2D, 3D, and Stereo views coupled with animation, color, and sound may all be appropriate at different times in different situations. Some of the potential situations need to be explored and rules and guidelines need to be codified for the implementation of such systems in an open architecture environment. The effective integration of a display system with a display depends in the end on the ability of the user's to see the data and understand it. Display technologies that provide the best contrast, view angles, and resolution should be explored to deliver the best overall system.

PHASE I: Develop a feasibility concept for a total system including display management system, approaches to implement the "best" format, and candidate implementation platform(s).

PHASE II: Develop a prototype system and demonstrate the ability to manage information across two functional areas simultaneously. Present the full range of expected actions in each of the functional areas using all the presentation formats appropriate to the problem. Provide demonstration of the ability to interconnect the system with multiple sensors, ship system or combat system elements using the open architecture. The functional areas should be as broadly based as practical.

PHASE III: Incorporate the decision support architecture into a set of selected warfare support areas.

COMMERCIAL POTENTIAL: This product is directly applicable to commercial transportation systems, power plant operating systems, and other operational environments where high stress, rapid response actions are required.

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KEYWORDS: Display, Software, Decision Support, Stereo, Three-Dimensional

N02-041 TITLE: Radar Technology/Unit Cost Reduction

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT III: PMS 452/PMS 426 Navy Theater Wide Ballistic Missile Defense (NTW)

OBJECTIVE: The Navy continually investigates diverse technologies for both TBMD and TAMD applications. As such, advanced radar technology demonstrations for affordability and advanced industrial practices to demonstrate both improved manufacturing processes and improved business methods are of interest. Proposed efforts funded under this topic may encompass any specific manufacturing process technology at any level resulting in a radar, array subsystem, or T/R module unit cost reduction. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

DESCRIPTION: Drastically lower unit cost of radar components and subsystems through manufacturing revolutions will lead to affordable high volume production. This will result in an improvement in the affordability of new ballistic missile defense radar systems and the development of cost effective methods to sustain existing developments while impacting the next generation of acquisition systems. High unit cost reduction through the development of high volume commercial items that fill military radar requirements are required. Innovative approaches that will allow low cost procurement of new technologies for the next generation of ballistic missile defense systems and maintain these systems while providing for their upgrades will make total life-cycle costs more affordable. Innovative manufacturing technologies which reduce the cost per unit, repair, or remanufacturing/reengineering of entire radar sensor systems, components, sub-components, or piece part specifics are specifically solicited.

PHASE I: Proof of concept that new and innovative research and development approaches can meet needs for future radar systems.

PHASE II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

PHASE III: Develop pre-production and production components and sub-systems for integration into Navy surface combatants.

COMMERCIAL POTENTIAL: These technologies could be applied in many RF applications such as the telecommunications industry, commercial airport radar systems, and automotive industry.

REFERENCES:

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KEYWORDS: Radar, T/R Module, HPA, Wide Bandgap, Wide Bandwidth, Thermal Management

N02-042 TITLE: Low-Cost Wireless Shipboard Local Area Network

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IVT: PMS 400F - Smartship Integrated Ship Controls (ISC)

OBJECTIVE: Develop innovative enabling technologies/approaches/systems/processes to enable the increased shipboard use of wireless Local Area Networks (LANs) by reducing the costs for system acquisition and installation.

DESCRIPTION: Commercial applications of wireless radio frequency (RF) LANs have matured extensively over the past 3 years. Navy wireless information technology (IT) systems are being developed for increased shipboard information gathering for logistical, personnel, and maintenance-related systems. Shipboard wireless systems offer simplified adaptability for COTS technology refresh over long shipboard lifecycles and are particularly applicable for collecting system data/information from multiple remotely located systems and for mobile access to computer networks.

Wireless LAN installations can promote lifecycle cost savings over conventional "wired" networks through simplified reconfiguration in response to new technology or mission/requirement changes. The objective of this initiative is to reduce the acquisition and installation costs to achieve a ship-wide wireless LAN through innovations in technologies/approaches/systems/processes. Acquisition and installations costs current are a major impediment to wireless LAN exploitation throughout the Fleet. Schemes that include dual operating modes, such as inclusion of InfraRed (IR) communications, are especially desirous. Use of Open System Architectures standard interfaces is essential to enable increased shipboard exploitation of commercial systems over long ship lifecycles.

PHASE I: Develop affordable, innovative wireless LAN enabling concept that results in reduced acquisition/installation costs for shipboard use.

PHASE II: Analyze and demonstrate feasibility of approach developed in Phase I in both laboratory and shipboard environments. Document approach and impacts on capability, acquisition, installation and lifecycle costs. Demonstrate cost reduction approaches under multiple scenarios simulating operational conditions to evaluate capability, security, and electromagnetic interference/compatibility.

PHASE III: Develop transition plans and demonstrate the commercial and shipboard use of approach. Demonstrate cost reduction approaches under multiple scenarios simulating operational conditions to evaluate capability, security, and electromagnetic interference/compatibility.

COMMERCIAL POTENTIAL: Wireless technology represents one of the fastest growing sectors of the IT market. Wireless LANs are in use in a number of commercial applications including industrial plants, office buildings, universities, etc. The upfront costs of wireless LAN installation remain an impediment to increased proliferation. Schemes that reduce these costs for shipboard use are easily transferable to land-based use. Security and Open Systems Architecture interfaces are especially prevalent concerns in the commercial market.

REFERENCES:

1. ISNS PPL/QPL Test Report: Wireless Local Area Network (WLAN), August 31 2000, SPAWAR, Rev 2.1, Integration Test Facility, SSC SD. (Report available in Adobe Acrobat format from topic writer)
2. USS The Sullivans Wearable PC and Wireless LAN Electromagnetic Interference and Threat Analysis Test Report, 15 October 1998, PEO Theater Surface Combatants, PMS-400F7. (Report available in Adobe Acrobat format from topic writer)

KEYWORDS: Wireless, RF, Local Area Network, LAN, WLAN, Open Systems Architecture

N02-043 TITLE: Long Range Wireless Network Communication Capability

TECHNOLOGY AREAS: Information Systems, Electronics

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT ID: PMS 465 - Cooperative Engagement Capability (CEC)

OBJECTIVE: Develop an innovative long range communication capability to form a wireless network between operating units.

DESCRIPTION: The radio frequency spectrum is congested with a variety of users from citizens and businesses. This is being exacerbated by the development of third generation (3G) and fourth generation (4G) wireless systems for mobile voice and Internet-accessibility. Current long range communication systems must contend with a variety of interfering signals as well as insure that they do not interfere with other narrowband radio systems operating in dedicated bands. These concerns could be alleviated by using an approach that has minimum RF interference, such as UWB technology, plasma antenna or using technology, which doesn't operate in the radio frequency spectrum at all.

Develop a communications system, which can form a long range wireless network between moving operating units. Technologies such as ultra wideband (UWB), plasma antenna or non-radio frequency (non-RF) spectrum should be considered. The approach must operate reliably in all kinds of weather. The system must accommodate a high-speed data rate with extremely low latency. The effective range must be suitable for communicating between sea/land borne stations and aircraft. Line-of-site range is a minimum requirement. Approach must minimize or control propagation anomalies, have no health hazard to humans and be environmentally friendly.

PHASE I: Conduct a feasibility study for an innovative communications system which is all weather, has a high-speed data rate with extremely low latency, and can operate over long ranges (at least to the horizon) between moving operating units. Document concept and possible design.

PHASE II: Develop and document the prototype communications system identified in PHASE I. Build a prototype system using several stationaly and moving nodes in order to demonstrate its networking capabilities as well as its ability to met the various performance and safety requirements.

PHASE III: Integrate the prototype communications system with a Navy system in order to see how effective data can be passed between the nodes. Demonstrate system by doing field tests. Develop and produce a fieldable system.

COMMERCIAL POTENTIAL: The wireless communications industry is the predominant target market in the commercial sector. Non-RF, UWB or plasma antenna networking will help commercial and military applications which are being crowded out of currently used radio spectrum.

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KEYWORDS: Long Rang Wireless Networking, Non-Radio Frequency Communications, Ultra Wideband Communications, Plasma Antenna

N02-044 TITLE: Non-destructive Battery Inspection Techniques

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II: PMS 422 - Standard Missile Program

OBJECTIVE: Reduce Total Ownership Cost of primary, remotely-activated batteries by reducing the number of samples destructively tested for Quality Evaluation Testing.

DESCRIPTION: Many weapon systems use primary, remotely-activated batteries to provide electrical power during their use. The use of this type of battery provides the benefit of long shelf-life however they are subject to aging degradation from a variety of sources. Quantitative analysis of the stockpile requires the activation of a number of samples on a routine basis, after which statistical techniques are used to project the results to the entire stockpile. The process of selecting samples, removing them from the weapon, procuring replacement samples, testing and analyzing the data is costly. If a method could be developed which would provide information from which the performance of the battery could be inferred with a high degree of statistical confidence the TOC for the weapon system could be significantly reduced. These batteries are one-shot devices (see reference 1). Once activated they provide power for a short period of time and then are expended, with no re-use or recharge possible. Non-invasive, non-destructive techniques are needed to evaluate the electrochemical decomposition of the batteries during storage.

PHASE I: Investigate potential methods non-destructive inspection of batteries used the STANDARD Missile. The battery chemistries of interest are zinc/silver-oxide, lithium aluminum/iron disulfide and lithium silicon/iron disulfide. Develop list of candidate methods to be further investigated in Phase II.

PHASE II: Further investigate candidate methods and demonstrate the feasibility of each.

PHASE III: Implementation of successful methods by weapons programs.

COMMERCIAL POTENTIAL: This technology could have application in other industries that would benefit from improved non-destructive inspection techniques.

REFERENCES:
1. Linden, David, "Handbook of Batteries and Fuel Cells" 2ed. McGraw-Hill.

KEYWORDS: Electrochemical, Thermal, Battery, Power

N02-045 TITLE: Thermal Management

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT III: PMS 452/ PMS 426 - Navy Area Theater Ballistic Missile Defense

OBJECTIVE: Radar antenna and T/R module thermal management and cooling technologies are critical for today's high power radars. A significant investment is made each year in the continued development of increasingly robust and sophisticated cooling system technologies, which are applied to the ballistic missile technology program and other major defense acquisition programs. Furthermore, radar thermal management systems, components and sub-components are constantly under review for upgrade by the latest technology developments from industry. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

DESCRIPTION: Higher power levels of future Navy radar antenna systems require state-of-the-art capabilities for waste thermal energy acquisition, transport, and dissipation. Technology advancements are required in thermal

management for power generation systems, T/R modules, and all associated electronics. Concepts, devices, and advanced technologies for all types of power cycles are sought, which can satisfy projected shipboard radar system requirements.

PHASE I: Identify potential new and innovative research and development approaches to meet the thermal management needs discussed in this topic.

PHASE II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

PHASE III: Develop pre-production and production components and sub-systems for integration into Navy surface combatants.

COMMERCIAL POTENTIAL: These technologies could be applied in many RF applications such as the telecommunications industry, commercial airport radar systems, and automotive industry.

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11. W.C. Nieberding, J.A. Powell, "High-temperature electronic requirements in aeropropulsion systems", IEEE Trans. Industrial Electronics, pp. 103-106 (1982).

KEYWORDS: Radar, T/R Module, HPA, Wide Bandgap, Wide Bandwidth, Thermal Management

N02-046 TITLE: <u>Ruggedization of Damage Control Equipment to Meet Shock Qualification Criterion</u>

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT 1C: PMS400D (DDG 51)

OBJECTIVE: Develop a low cost system(s), which has varying static properties and provides dynamic shock mitigation for sensors, cameras and smart valves. The system(s) should be capable of meeting or exceeding individual component and system shock performance specifications as identified in MIL-STD-901D.

DESCRIPTION: The Advanced Damage Countermeasures (ADC) program will demonstrate improved damage control automation to include an anticipatory damage control response mechanism to help reduce the energy release rate from internal shipboard explosions and also identify an embedded sensor strategy and computing engine for automating stability/hull damage assessment.

The ADC program is divided into four independent program elements that include; the development of an Advanced Volume Sensor, the development of an Automated Hull Damage & Stability Monitoring System, the development of a High Efficiency Water Mist technology and the introduction of a Water-based Blast Mitigation System.

Advanced Volume Sensor: A detection scheme and data analysis method for a remote real time optical sensor that is in development. The Optical sensor will utilize both spatially and spectrally resolving capabilities. The spatial approach will involve using a movie camera and analyzing the images for shapes and movement of shapes that are characteristic of selective events such as fire and explosions. In the spectrally resolved approach, molecular emission is detected, which could be in the ultraviolet of the infrared or both using point detection or a camera.

Automated Hull Damage and Stability Monitoring: This effort is to develop a monitoring system that will automatically sense structural defects and flooding status, calculate and predict stability condition, and recommend and initiate actions as appropriate. The rupture and detection and instrumentation will include: ultrasonic sensors for hull rupture and defects; level sensors in all spaces to provide both pressure head and liquid levels; sensors to provide hatch and door status; manual input. The detection strategy and stability-computing engine will then be integrated to calculate and recommend or execute possible control actions to stabilize the ship.

High Efficiency Water Mist System: In recent years water mist has been gaining wide acceptance in fire fighting both as a Halon alternative and as a substitute for conventional sprinklers. Most of the research effort to date has focused on the machinery space and general hazard protection using high-pressure water mist generating systems. This effort will continue to build on these previous studies and evaluate alternative methodologies to further improve the application of water mist technology for electronic space fire protection.

Water-based Blast Mitigation System: This concept injects a fine water spray into compartments in the vicinity of a missile hit. The cloud of water droplets would then reduce the blast effects of the exploding missile warhead. The focus of this effort is the demonstration of a reduction in peak overpressure and minimization of the resulting blast damage area. A likely outgrowth of this effort is a ship-wide water mist system having dual utility: a fire suppression system for peacetime fires and a system of blast mitigation in combat scenarios.

Additional information with respect to the four independent program elements of the ADC program will be available upon request.

The Navy recognizes that one solution may not fill all applications; however, simplicity and commonality of solutions will be favorably weighted. Extra consideration will be given to proposals that provide static and dynamic load mitigation to a broad range of marine equipment, not just fire detection, fire-fighting and damage control equipment.

PHASE I: Develop a system configuration which, through a combination of analytical (and) experimental means, will exhibit potential for providing shock mitigation in accordance with the Navy's specifications. Identify configuration requirements that must be considered in development. Develop/identify potential low cost fabrication methods for manufacturing the systems.

PHASE II: Transition analytical/experimental findings into prototype concepts. Design, fabricate and characterize the static and dynamic properties of the concepts. Fabricate associated hardware and conduct shock testing to assess performance. These shock requirements should be established with Navy support. Develop and deliver product specifications including performance and mechanical properties for evaluation. Provide prototypes for sea trials where shock mitigation is required, particularly in harsh and corrosive environments.

PHASE III: Develop these concepts and products for use with low cost Commercial-Off-The-Shelf (COTS) fire detection and damage control equipment, which will result in very large cost savings for the Navy. Transition concepts to the fleet through installation for applicable fleet applications.

COMMERICIAL POTENTIAL: This type of system could be utilized in numerous industrial applications where shock is an issue of concern. The potential use is very wide, which includes rotating and reciprocating equipment, and

isolation of precision equipment.

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7. MIL-STD-901D

KEYWORDS: Shock Isolation, Corrosion Resistance

N02-047 TITLE: Low Volume, Low Power, Real Time Image Processing

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II: PMS 422 - Standard Missile Program

OBJECTIVE: Develop new data processing technologies that can execute real time spatial and temporal processing of 2D (and 3D) image data to locate, identify and/or track objects in the image field. New technologies must emphasize a minimization in volume and power consumption characteristics.

DESCRIPTION: Imaging sensors with increasingly higher resolutions are becoming more prevalent in battlefield applications. These higher resolution optical and RF sensors place substantial demands on current processing methodologies and technologies to rapidly process the presence, motion and profile(s) of objects within the sensor's field of view. Much of this effort is to segregate increasingly complex objects from increasingly complex backgrounds. As a consequence, the data processing systems for these sensors tend to be large, complex and power demanding. These features preclude use or full employment of high resolution sensors and their complex image processing systems aboard small platforms. To alleviate these concerns, the Navy is seeking new processing technologies to rapidly assess the spatial and temporal characteristics of both objects and background in order to detect, identify and track previously characterized objects. The new technology must be able to assess translational and rotational motion and spatial profiles (when resolved) of objects against both static and non-static background features. Innovations in minimizing volume and power consumption and maximizing computational through-put will be sought. The Navy is seeking to apply this technology to both passive and active sensor/seeker systems for missiles and satellites so volume, weight, reliability and power requirements are a concern.

PHASE I: Develop concepts and design approaches that substantiate an achievable, highly parallel data processing technology. Identify nominal sensors and object/background characteristics that will be used to establish performance guidelines. Fully describe the theory of operation of the new data processing technology. Provide a detailed description of how the new technology will assess spatial and temporal image features to segregate the object from the background. Provide analysis showing conceptual performance characteristics and limitations.

PHASE II: Design, build and test a prototype system based on the technology products of Phase I. Based on the

nominal sensor and object/background characteristics used in Phase I, show the ability to detect, identify and track individual and multiple objects. Identify probabilistic performance characteristics such as probability of detection/false detection, probability of identification/false identification, and probability of track/false track. Show how the design might perform for alternative window profiles relative to thickness and shape (such as spherical, conical or flat) based on projected steady-state aerodynamic effects. Explain variations in volume and/or power consumption relative to the projections established in Phase I.

PHASE III: Transition to advanced development of a full-up design and production package.

COMMERCIAL POTENTIAL: Optical sensors properly enhanced with this data processor can conduct autonomous commercial security surveillance, facial recognition and remote steering.

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KEYWORDS: Data Processing; Spatial Processing; Image Processing

N02-048 TITLE: Automated Battery Assembly

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II: PMS 422 - Standard Missile Program

OBJECTIVE: Reduce Total Ownership Cost of thermal batteries by reducing touch-labor, reducing rejects, and improving reliability

DESCRIPTION: Present manufacturing techniques for manufacturing of thermal batteries utilize a significant amount of touch-labor for the assembly process. The battery components (anode, cathode, electrolyte/separator) are made from pressed powders formed into a circular shape with a center hole (see reference 1). These are called pellets. The pellets range in thickness from a few thousandths of an inch to several tens of thousandths. In general, pellet thickness increases with diameter in order to maintain mechanical integrity. The larger pellets, such as found in the Aegis ER booster battery (reference 2). After pressing the pellets are inspected , transferred to storage containers and transitioned to the production line. On the production line the various pellets, along with current collector disks, are stacked in the correct order on a mandrel. This entire process is manual and places the battery components at risk of damage each time they are handled. Each battery consists of a number of pellets which may be over several hundred in total. The manual processing can lead to stacking errors (something out of order) and pellet damage. Both of these can lead to catastrophic battery failure.

PHASE I: Review processing flow at one or more thermal battery manufacturers. Determine mechanical properties of conventional pressed powder pellets. Investigate alternative methods for handling the components of thermal batteries

during assembly. Perform a preliminary design of prototype system

PHASE II: Develop and demonstrate a prototype automated assembly system that can readily be integrated with thermal battery production processes.

PHASE III: Commercialization of automated system

COMMERCIAL POTENTIAL: This technology could have application in other industries that require handling of fragile or sensitive components such as silicon wafers, sapphire windows, etc.

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2. Naval Sea Systems Command Critical Item Development Specification L6522781. Booster thermal battery SM-2 Block IV (Aegis ER).

KEYWORDS: Electrochemical, Thermal, Battery, Power, Affordability, Manufacturing

OFFICE OF NAVAL RESEARCH (ONR)

N02-049 TITLE: Technology for Shipbuilding Affordability

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

OBJECTIVE: The objective of the project is to develop and implement innovative technologies that will reduce the cost of ship construction, thereby improving the competitiveness of the domestic shipbuilding industrial base and reducing the cost of military ships.

DESCRIPTION: US shipyards along with suppliers, owners, operators, and government personnel have developed the NSRP Advanced Shipbuilding Enterprise (ASE) Strategic Investment Plan, which reflects an industry led strategy to promote commercial competitiveness and reduce the cost of military ships. The plan identifies five (5) major initiatives and the associated sub-initiatives as R&D requirements for this industry. The entire plan is available for review on the World Wide Web at http://www.nsrp.org/. Of particular interest are initiatives directed toward implementing lean-enterprise concepts. Proposals under this topic must address at least one of the five research areas and sub-initiatives listed below:

1. INDUSTRIAL ENGINEERING/PRODUCTION ENGINEERING
Develop and provide to the industry standard process analysis tools that, when packaged together and fully implemented, will support the realization of process improvements (and thus reduced costs and cycle times) across all production areas. This research area is considered to be key to the industry's successful transition from a "custom construction" to "world-class manufacturing" shipbuilding approach. Industrial Engineering/Production Engineering elements may include:
*Process mapping and analysis methodologies
*Production process simulation modeling
*Manufacturing process metrics
*Standard interim product development methodology
*Design for Production rules
*Set-up reduction methods
*Standardized work
*Visual control methods
*Cellular/flow manufacturing
*Value Stream Mapping
*Layout methods to support flow manufacturing

2. MANUFACTURING TECHNOLOGIES
Develop, pilot, and provide to the industry, manufacturing technologies (e.g., surface preparation and coatings, welding and joining, forming, etc.) process and/or material improvements that would result in measurable labor, cycle time and/or material savings. Focus areas to be considered include:
*Edge preparation technologies for removing sharp corners on profiles and plates
*Increased use of weldable preconstruction primers
*Alternative blast media and systems
*Portable/flexible containment systems
*Coating automation
*Joining technology
*Inspection methods and processes
*Material cutting, forming, and processing
*Cost-effective safety, health, and environmental improvements to these processes

3. STRUCTURAL PROCESSES
Define, pilot and provide to industry, manufacturing technology process and/or material improvements that would result in measurable labor, cycle time, and/or material savings. Recommended areas of focus are:
*Use of standard interim products
*Value Stream Mapping
*Cellular/flow manufacturing
*Part fabrication accuracy
*Improved process control techniques
*Process rationalization and automation
*Staging and scaffolding
*Material handling
*Joining technology
*Inspection methods and processes

4. ADVANCED PRODUCT DESIGNS AND MATERIALS
The Advanced Product Designs and Materials sub-initiatives include the identification and development of new and "breakthrough" product designs and advanced materials required to ensure U.S. shipyards market differentiation in the ships of the future. Potential developments under this initiative may include shallow draft ocean going designs, automated cargo handling capability, advanced propulsion systems, standard integrated control systems, reduced shipboard manning capability, designs for improved shipboard maintenance and safety, advanced adhesive products, innovative fire protection systems, unstiffened curved plate arrangements, protective coatings, and advanced composite structures (NRC, 1996). Another sub-initiative may be the regulatory implications associated with promising advanced product designs and materials.

5. COMPUTER-AIDED MANUFACTURING (CAM) INTERFACES
An important aspect of shipyard integration (which has been largely ignored) involves the problem of exchanging a ship design between different CAM systems. Projects in this area should focus on developing an environment where the evolution of CAD systems is decoupled from the CAM systems, enabling yards to add new CAD systems by adding only one pathway to a neutral format CAM database. Improvements in either CAD or CAM can be brought on line with little impact to the other.

Multiple Phase I awards to the highest rated proposals overall are planned (awards will not be set aside within each topic area). However two (2) additional Phase I awards will be made to firms with a cooperative research and development agreement with a foreign firm that has demonstrated significant advances in the construction, outfitting, operation, maintenance, and repair of commercial ships. The proposal title should indicate which of the 5 areas and subtopics are being addressed, and the proposal should describe the technology that will be developed to solve the problem, how it will be developed, and what the estimated benefits will be, as well as how it will be transitioned into the shipbuilding industry. Coordination with U.S. shipbuilders to adapt and implement "World Class" commercial best practices is encouraged. Teaming with the shipbuilding industry to form integrated project execution and implementation team will improve transition potential and is strongly encouraged.

PHASE I: Prove feasibility of improvements to be developed and detail where and why they will impact shipbuilding affordability. Include a Return-On-Investment (ROI) analysis for industry implementation and close collaboration with a shipyard customer to validate feasibility.

PHASE II: Develop a working prototype production system or prototype product to demonstrate its performance characteristics. Present the technology being developed to the NSRP ASE Major Initiative and technology panels, develop a commercialization (Phase III) plan, in coordination with NSRP ASE members, including descriptions of specific tests, evaluations and implementations (including sites and points of contact) to be performed.

PHASE III: Implement the Phase III plan developed in Phase II in coordination with the NSRP ASE Program.

COMMERCIAL POTENTIAL: The technology developed under this topic shall be applicable to commercial shipbuilding practices and marketable to the global shipbuilding market.

REFERENCES:

1. NSRP ASE Strategic Investment Plan and shipbuilding industry contacts are available on-line at http://www.nsrp.org/

KEYWORDS: Shipbuilding, Affordability, Production, Manufacturing, Processes, Maintainability

N02-050 TITLE: Predictive Durability Model for Life Extension of Naval Waterfront Concrete

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop an analysis process that can be used to predict the life-cycle costs for existing Navy waterfront concrete facilities. This analysis process will be applicable to the maintenance and repairs for reinforced concrete structures exposed to the marine environment. The analysis process will also compliment the available industry modeling software by incorporating marine concrete and specifically U. S. Navy marine concrete historic performance. Deterioration mechanisms beyond chloride-induced corrosion will also be evaluated (i.e., ASR, sulfate attack, DEF, and carbonation).

DESCRIPTION: An analysis process is needed to allow Navy engineers to predict the cost/benefit of using various maintenance and repair technologies for existing concrete waterfront structures. This process can also be applied to new construction materials and processes. Because there are virtually thousands of ways of formulating the materials and chemical admixtures to produce an optimum design for the local environmental conditions it is necessary to develop discreet models relating concrete chemistry options and the specific attack modes. The contractor shall address the following attack modes.

* Corrosion of the steel reinforcement due to ingress of chloride ions
* Alkali-aggregate reaction (ASR)
* Sulfate attack
* Delayed ettringite reaction (DEF)
* Corrosion of the steel reinforcement due to carbonation

The model will be developed so that the user can optimize the concrete mixture to resist more than one of the likely attack modes. In addition the contractor shall develop an environmental model of the atmosphere, sea and soil/land factors that determine the most likely exposure that dominate the failure mechanisms.

The design team must include concrete chemists, concrete modelers and concrete materials practitioners experienced in design, maintenance and repair of marine concrete. The government will accept proposals from innovative firms competent in concrete design and concrete practice and skilled in modeling the concrete chemistry and failure mechanisms.

PHASE I: Develop a plan to characterize exposure and performance of Navy waterfront structures. Collect initial relevant field data capturing analysis parameters (permeability, corrosion initiation, corrosion rate, ASR, sulfate attack, DEF, and carbonation. Develop Navy specific analysis parameters for analysis, and transfer initial Navy parameters to industry modeling committees (SDC, ACI, and ICRI).

PHASE II: Validate the Proposed Methodology Characterize exposure and performance of Navy waterfront structures. Expand evaluation scope to generate statistically confident Navy analysis parameters. Incorporate the specific Navy analysis parameters into the state-of-the-art industry modeling software.

PHASE III: Marine concrete performance will be summarized in current durability analysis terminology. Detailed field structure analysis will provide valuable input parameters for industry available modeling software.

COMMERCIAL POTENTIAL: Industry modeling software will be strengthened by Navy data for chloride ingress, ASR, sulfate attack, DEF, and carbonation.

N02-051 TITLE: Movable Platform for Deep Water, Wave Power Generation

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

OBJECTIVE: Study and derive an approach to extract energy from ocean waves in deep water. The desirable characteristics of the system should be such that it be a modular, floating, movable or self propelled platform capable of producing usable electrical power in the range 100 kW to 10 MW from the energy in deep water (greater than 100m), ocean waves.

DESCRIPTION: Several technologies and system configurations have been investigated in the past to convert the large amounts of mechanical energy present in ocean waves into electrical energy. These earlier approaches, some of which are now entering commercialization phase, have utilized wave power systems that have been moored in shallow water (less than 50m) or are positioned on the shoreline or a breakwater. Such systems are intrinsically permanent. There is both a military and a commercial need for a wave power electrical generation system mounted on a floating and easily movable platform that can harvest significant amounts of energy from deep-water ocean waves. Such a system would greatly reduce dependence on the need for fossil fuel (diesel or natural gas) that is traditionally used in remote, portable power systems. Fossil fuel becomes very expensive to deliver to remote locations. Also in times of conflict, the transportation route becomes vulnerable for interdiction. A self contained, movable wave power system should be able to efficiently operate in water depths between 100 m and 2000 m and should be able to produce electrical power of up to 10 MW. The power generation system should be modular in nature and the platform and the power system should be easily and quickly deployable. Military applications would include providing reliable, electrical power at a beachhead established by the Marines in an amphibious landing.

PHASE I: Develop innovative concept and preliminary design of a movable, deep-water wave power generation system. Design factors that will be evaluated will include ocean wave specifications, sea bed conditions, and anchoring specifications, electrical power produced, type and amount of hybrid power system needed to supplement wave power generators, size and weight of power generation system and movable platform and estimate of the cost of the system.

PHASE II: Design, build and test in a wave tank a scale model of a movable, deep water, wave power electrical generation system. Report the system's performance.

PHASE III: Design, build and ocean trial at a site chosen by USN or USMC, a prototype wave power electrical generation system mounted on an easily deployable and movable ocean going platform. Detailed testing will be performed over a period of 12 months.

COMMERCIAL POTENTIAL: The movable wave power generation system has many commercial applications. These include remote power for coastal and island communities. Power for offshore platforms.

REFERENCES:
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KEYWORDS: Remote Power, Renewable Power, Wave Power

N02-052 TITLE: Computational Physics and Chemistry for Novel Materials

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO- Expeditionary Logistics; NAVFAC - Expeditionary Warfare

OBJECTIVE: To develop a systematic approach that will lead to efficient synthesis methods of novel materials, with emphasis on understanding the underlying quantum mechanical, physical and chemical properties that allow reliable pre-calculation of such characteristics as: high-hardness, high-strength, enhanced and/or oriented transport of electrical and thermal currents, high-temperature superconductivity, and switchable control of optical parameters (including those which result in directed transparency and spectral selectivity).

DESCRIPTION: A fundamental problem in computational solid-state physics and chemistry involves the development of a simulation program that accurately describes synthetic materials prior to laboratory production. For example, a hallmark case in which computational physics was successfully applied to the design and analysis of a material - prior to its laboratory synthesis - was the development of Boron Nitride by Marvin Cohen of U.C. Berkeley. Since current state-of-the-art analyses are becoming capable of characterizing bulk material properties of technological interest, computational exploration may now yield answers which would otherwise be too costly to seek in the laboratory. Accordingly, the goals of this program include development of a computation engine based on general principles which: (a) yields results that compare accurately with known properties in a representative sample of test cases, and (b) can be extended to yet-to-be-explored materials.

PHASE I: Develop a computation engine which yields results that compare well with the known properties of a representative sample of material test cases.

PHASE II: Prove the concept by extending the computation and comparison to an extensive list of known interesting materials. Synthesize and fabricate a new material selected to enhance a property of interest.

PHASE III: Open the exploration by prescribing new materials with properties of interest, then derive and optimize synthesis procedures to yield these materials.

COMMERCIAL POTENTIAL: Novel materials with high-hardness; high-strength; enhanced and/or oriented transport of electrical and thermal currents; high-temperature superconductivity; switchable control of optical parameters; and directed transparency and spectral selectivity represent enormous commercial opportunities.

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p7767 (1997)
4. J. K. Freericks, et al, "First Principles Determination of Superconducting Properties of Metals," Physica B, v284-288 (2000) p425-426

KEYWORDS: Hard Materials, High-Temperature (High T_C) Superconductivity, Directed Transparency

N02-053 TITLE: Characterize and Optimize ATR Performance for EO/IR Sensors

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: TMPC (ACAT II), APS (ACAT III), Joint Signal and Image Processing System - Navy (ACAT III)

OBJECTIVE: Development of methods to characterize and optimize ATR performance, specifically to address tactical electro-optical and infrared reconnaissance and surveillance imagery that will lead to the ability to build predictive models that will provide robust ATR.

DESCRIPTION: There are several highly effective ATR algorithms that address detection, classification, and recognition for SAR sensor imagery data, which exploit the scattering physics and sensor phenomenology. However, due to the complexity of EO and IR sensor images and their variability due to atmospheric conditions, thermal history of the objects, illumination, and the impact of other environmental and background factors, an operational adaptive ATR that exploits the sensor phenomenology and target signatures is not available.

Ongoing research efforts are directed towards the characterization and optimization of EO and IR ATR systems in general. This research program is specifically directed towards emerging needs within the Navy. In 2003 the Navy will begin fielding and support the Shared Reconnaissance Pod (SHARP). SHARP features two sensors, one electro-optical (EO) (operating wavelength 0.4-0.9ƒÝ) sensor and one Medium Wave (MW) (operating wavelength 3-5ƒÝ) infrared (IR) imaging array. The EO imaging array consists of a 5040 x 5040 pixel array operating with a field of view (FOV) of 1.350 at high altitude (approximately 45000 ft) or a 6.30 in medium altitude (approximately 20000ft). The IR sensor consists of a 1968x1968 pixel focal plane array with a FOV of 2.270 at high altitude. The primary mission in which SHARP will be employed is to detect, locate and identify high value stationary and moving targets including critical mobile missile launchers in a variety of backgrounds and clutter condition.

It is expected that the output of these sensors will produce a data stream that overwhelms conventional ATR systems and manual approaches based upon operator screening, leading to missed detections of targets if current technology is applied. Image analysts (IA) are expected to monitor data streams produced by SHARP and use highly compressed thumbnail images for target detection and recognition. An operating condition that is difficult at best and which becomes prohibitive at the data rates produced by SHARP. An important future goal is to migrate the target detection and recognition technique to the sensor platform directly, thus reducing large communication bandwidth requirements, and potentially minimizing the timeline associated with time critical strike. Finally, ATR developments supporting the SHARP sensor suite will provide a technology foundation for other larger imaging arrays currently in development for DOD and civilian applications.

Present university and industry research continues to focus on common aspects of ATR ranging from performance characterization, optimization, reducing dimensionality to the effect of training sample size on performance and training sample size requirements. Considerable progress has been made to date but there is still a lack of a functional ATR for EO/IR based sensors. More fundamental research is needed that focuses precisely on the ability to embed sensor characteristics (phenomenology) into the ATR as has been done with SAR systems and to provide adaptation based upon sensor performance. Considerable performance improvements of the EO/IR ATR system are expected with the ability to incorporate sensor performance characteristics and adaptation into the processing algorithms. Furthermore, an understanding of basic ATR elements and characterization and optimization of ATR performance using the underpinnings developed under DOD sponsored research need to be continued and directed towards specific sensors. This will lead to the ability to build predictive models that will ultimately produce a more robust ATR.

PHASE I: Develop a mathematical formulation of EO/IR ATR, which enables detection, characterization, optimization, and adaptation of EO/IR in support of the SHARP mission. The formulation should be based upon an understanding of basic ATR elements that include models of sensor performance, environmental effects, background variation, and target signature of time critical targets using the operating parameters appropriate to the SHARP mission, and be flexibile enough to support other systems.

PHASE II: Use actual fielded Government Off-The-Shelf (GOTS) hardware such as the Tactical Input Segment (TIS), Precision Targeting Workstation (PTW), and/or a developmental system such as the PTW Advanced Concept Environment (PACE), to show feasibility, demonstrate, and validate the performance of the ATR methods that are to be developed in Phase I. The specific goal is to define algorithm optimization requirements, overall performance characterization, optimization, and tuning of the algorithms balanced against operational requirements (throughput, timing, etc) in a fleet fielded system.

PHASE III: In this phase ATR algorithms and processors will be totally integrated into a workstation in full operational condition.

COMMERCIAL POTENTIAL: This capability can be applied to the commercial market sector in a wide range of applications that includes remote sensing, industrial machine vision, and medical imaging.

KEYWORDS: ATR, Automatic Target Recognition, ATR Performance, EO/IR Sensor

N02-054 TITLE: High Depth-of-Field Panoramic Video Acquisition and Analysis of Dynamic Scenes

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Battlespace

OBJECTIVE: Design and demonstrate a sensor for uniform, high resolution, high depth-of-field, imaging of dynamic scenes, and develop techniques, algorithms, and software to exploit the resulting video for scene analysis.

DESCRIPTION: Standard video cameras acquire high-resolution and focused video for a small chosen volume of a scene. The volume for which focused images are obtained has limited extent, both laterally and in depth. To image large visual fields with large depth of field, imaging parameters, such as viewing direction and depth-of-field, need to be varied. New sensors are needed to achieve maximal possible resolution globally while still allowing selective attention through analysis and controlled information blurring. The desired sensors would exploit physical (real-time) processes to achieve high visual acquity everywhere. Further, the sensors would be capable of estimating three-dimensional (3D) scene layouts. The design should allow the overall dual functionality of high-fidelity panoramic video acquisition for dynamic scenes and development of procedures for 3D analysis such as 3D visualization, 3D modeling and tracking.

Military applications of such a system include: battlefield visualization, remote manipulation in hazardous environments, situational awareness, surveillance and monitoring.

PHASE I: Develop a design for an imaging system that captures images at video-rate, has a wide field-of-view and a large depth-of-field, and provides depth estimates. Evaluate the feasibility of the design.

PHASE II: Develop the imaging system prototype. Develop techniques and software for scene analysis from acquired imagery. Determine reliability and limitations of the imaging system.

PHASE III: Demonstrate producibility and develop commercial applications for the imaging system.

COMMERCIAL POTENTIAL: Monitoring and security, 3D object/scene modeling, Visual art, Movies production, and Virtual environments.

KEYWORDS: Wide Field-Of-View, High Depth-Of-Field, Uniform Resolution, 3D Modeling, Video Camera

N02-055 TITLE: Parallel Patterning for Ultra-Submicron Magnetoelectronic Devices

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop and demonstrate the capability to pattern magnetic multilayer structures below .05 micron feature size using high throughput parallel processing techniques. Potential techniques include but are not limited to conventional DUV lithographic patterning of multilayers deposited on large wafers, novel dry-etch processing for transition metal materials, direct deposition of multilayered materials into constrained nano-structures, and chemical-mechanical polishing of magnetic materials.

DESCRIPTION: There is a critical need within DOD to develop high throughput techniques for fabricating magneto-electronic devices at scales below 50 nm, in order to optimize the materials and structures for high density, low power-consumption, radiation hardened, nonvolatile random access memory (RAM). Such nonvolatile memories are being developed based on the perpendicular giant magnetoresistance (GMR) effect, and are required to meet the speed and density requirements for future Navy electronic systems. Perpendicular transport through metallic multilayers requires laterally confined structures less than .05 micron in size to achieve the necessary signal strength and electrical resistance to be compatible with semiconductor electronics. Structures patterned from deposited multilayers must have smooth sidewalls and minimal damage to the magnetic transition-metal layers, to allow smooth, reliable switching of the magnetization. For direct deposition into confined structures, the magnetic layers must be uniform, flat, free of defects, with smooth interfaces and good control of layer thicknesses, and with no deposition on the sidewalls.

PHASE I: Demonstrate parallel patterning of features less than .05 micron in a magnetic/non-magnetic/magnetic trilayer structure. Result should exhibit close to full saturation magnetization, and separated individual magnetic layer switching in a magnetic field.

PHASE II: Extend the parallel patterning technique developed in phase I to multilayers (more than 3 layers) of thicknesses and material compositions suitable for GMR devices. The patterned structures should exhibit independent layer switching, magnetoresistance effects greater that 15%, resistances on the order of one Ohm and current capabilities of 107 Amp/cm2.

PHASE III: Transition will occur to a large scale manufacturer of random access memory via either commercial funding, ONR Mantech, or advanced development funding. Partners may include microelectronics foundries, etc.

COMMERCIAL POTENTIAL: Non-volatile RAM may make it possible to eliminate hard disks (combine cache, RAM, & HD) in a variety of computing applications, from personal computers, to personal digital assistants to cell phones. By eliminating the need to refresh existing semiconductor memories, power requirements will be reduced and ruggedness and reliability will be improved.

REFERENCES:
1. J. Zhu, Y. Zheng, and G. Prinz, J. Appl. Phys. 87, 6668 (2000).

KEYWORDS: Non-Volatile Memory, Submicron Lithography, Giant Magnetoresistance, Magnetic Multilayers, Microelectronics, Electronics Processing

N02-056 TITLE: Packaging and Thermal Management for kW/cm2 Microwave Amplifiers

TECHNOLOGY AREAS: Sensors, Electronics

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: Navy Theater Wide Ballistic Missile Defense

OBJECTIVE: Demonstrate practical and affordable techniques for packaging high power density (1 kW/cm2) wide

bandgap microwave power amplifiers.

DESCRIPTION: Wide bandgap semiconductor microwave amplifiers based in SiC and GaN are demonstrating record performance in prototype devices and amplifiers. For example, a discrete GaN transistor grown on a SiC substrate has demonstrated 50 W (pulsed) at 10 GHz in a die size of only 4 mm2 for a power density for the die of 1 kW/cm2. Initial reliability estimates, and the performance degradation with temperature, suggest that the transistor junction temperature should be maintained at 150 C or below. This implies that the reliable insertion of this technology into DoD systems requires improvements in die and module level thermal management. In addition, any thermal management approach must be consistent with the form factor of an active aperture array were each module must fit within a lambda/2 spacing

For this effort, 2 Cases should be considered for the wide bandgap amplifier: 1) an all SiC based 20 mm2 amplifier with 4 mil thick SiC with a room temperature thermal conductivity of 3 W/cmK, and 2) GaN-on-(4mil SiC) where the GaN is 1 um thick and has a thermal conducivity of ~2 W/cmK. Interest is in designs that support S- or X-band active aperture arrays.

PHASE I: The contractor shall develop and perform detailed thermal modeling of a thermal management design approach consistent with an X-band active aperture array employing a SiC or GaN-on-SiC amplifier technology that is dissipating up to 6 W/mm of power per unit gate width and a total power dissipation density of 1 kW/cm2 with a junction temperature „T 150 C. The design must address thermal expansion matching and be consist with conventional die attach and rework techniques or develop new approaches to for same.

PHASE II: Demonstrate packaged wide bandgap amplifiers (source of amplifier will be coordinated with program office) consistent with the items in Phase I. A manufacturing and cost model of the packaging technology must also be established.

PHASE III: The contractor should be able to compete in the market place for the packaging of high power density wide bandgap microwave amplifier for DoD and commercial market.

COMMERCIAL POTENTIAL: This work is expected to engender low-cost, wideband- tunable, low-distortion amplifiers for wireless communications.

KEYWORDS: Microwave Packaging, High Power Density, Wide Bandgap

N02-057 TITLE: <u>All-Weather Landmark Identification, Correlation, Geolocation, and Inertial Measurement Unit</u>

TECHNOLOGY AREAS: Materials/Processes, Sensors

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT III: PEO-Surface Strike (DD-21) PMS-529 NFCS – Naval Fires Control System

OBJECTIVE: The development of the Global Positioning System (GPS) by the DoD gave all of the Armed Services the capability to develop new systems that could benefit from the knowledge of precise location. However, in future conflicts, the capability of GPS will probably be eliminated, through either jamming or spoofing. Since the value of precise geolocation is very well appreciated by all of the Services, an alternative to GPS is needed for future conflict situations.

DESCRIPTION: This topic addresses the development and demonstration of the front end of a GPS-alternative system. This topic addresses the ability of a UAV to determine its geolocation independent of GPS. Other parallel efforts will address the technology required to harness the coordinated efforts of a number of UAVs possessing this capability to provide precise navigational information to other air and surface vehicles.

At the present time, a precise atlas of landmark data all over the world is being prepared for the DoD. These data will have an accuracy and resolution of about one meter and potentially could be used as an alternative to GPS for precise positioning. In order for this new system to be of value to the Navy, the system must be capable of locating and identifying these landmarks under nearly all weather conditions, be able to correlate their position with the landmark database, and then use these data to update an on-board Inertial Measurement Unit (IMU) in the avionics module.

The all weather requirement at low cost is a major portion of the challenge for this Topic. The selection, test, and evaluation of the most appropriate suite of commercial and developmental sensors is an essential portion of this effort. The sensor system must be capable of detecting geographic features in rain, fog, and clear weather, both day and night, to a resolution of approximately 1 meter (at a range of 500 ft to 5000 ft), comparable to the resolution of landmark data. The selection of sensors should be driven by the minimal suite of sensors that emphasizes very low cost of production in the final design.

The system platform is to be a very small Unmanned Air Vehicle (UAV) flying from 500ft to 5000ft altitudes. The overall final system must be limited to a maximum weight of 2 lbs. and use no more that 10 WDC power total. Passive sensors for acquiring the landmark data are to be preferred and might include very low light level video, infrared FPA, millimeter wave bolometer, or other such existing or developmental technology. The system will need to accurately identify the landmarks from these sensor images, be able to correlate these data with the database information in real-time (or near real time). The height above ground must be measured directly, and corrections for yaw, pitch, and roll of the platform at the moment of image acquisition by the sensor(s) must be included. Finally, these data must be compared with the current state of the IMU, checked for statistical reasonableness, and then if found to be acceptable, used to update and reset the IMU. The overall goal is to relocate absolute vehicle coordinates to within better than 5 meters in all three directions under nearly all weather situations 99.5% of all times. Final cost must be less than $2500/system in 1000 lot quantities.

PHASE I: Develop a proof of concept breadboard for a landmark identification and database correlation system that would be expected to be very low cost in production. Evaluate the system design using several data streams acquired by an air vehicle using the selected sensor package but processed on the ground. Validate the overall system using sensor data streams from two novel locations. Perform an analysis of system performance and assess the accuracy of position information to be expected under a variety of day/night weather conditions. Identify technologies limiting either performance or production. Provide an analysis with supporting documentation that explains how final design will meet or exceed cost, weight, size, power, and relocation accuracy objectives.

PHASE II: Design a brassboard version of the total system suitable for battlefield use (high EMI) and meeting weight, volume, and power requirements. Demonstrate brassboard system performance in an air vehicle in several diverse locations and environments. Compare system performance to an on-board, high accuracy GPS system. Provide a statistical analysis of the system performance and identify major sources of error and identify environmental conditions when poor performance might be expected. Measure system performance in a high EMI environment and adapt system design to enable good performance in these situations. Provide an analysis with supporting documentation that explains how final production design will meet or exceed cost, weight, size, power, and relocation accuracy objectives. Provide five functional vehicle level units for test and evaluation.

PHASE III: Demonstrate production capability with the construction and delivery of 25 functional systems. Estimate final cost of production.

KEYWORDS: GPS, Precision Location

N02-058 TITLE: High Energy, Long Pulse Laser

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II: PMS 473 - Advanced Integrated Electronic Warfare System (AIEWS)

OBJECTIVE: Develop, demonstrate, and deliver a laboratory brassboard high energy, long pulse visible/near infrared (vis/nir) laser that can be packaged for military and commercial platforms.

DESCRIPTION: Conventional high pulse energy vis/nir lasers available today offer pulse durations in the range <20 ns (q-switched or modelocked) or >100 microseconds (free running). The pulse-widths of these lasers are either orders of magnitude too short or too long for ship self-defense and some commercial applications which require pulse-widths on the order of 1 microsecond. Other challenges for this new laser technology include meeting compactness and ruggedness requirements for military platforms. Specific laser requirements for this effort include:

*Pulse duration 0.5-10 microseconds at all wavelengths
*Pulse Energy and wavelengths:
>1 Joule in the 0.4 - 0.8 micrometer region (at least two lines, line separation >0.2 micrometer, 1 Joule/line if lines generated sequentially,0.5 micrometer line undesirable), and
>0.5 Joule at 1 micrometer, simultaneous emission (1 Joule desired)
*Repetition Rate: nominally 10 Hz (higher pulse frequency desired)
*Beam divergence: 0.5 mrad

State-of-the-art dye lasers generate the required pulse energy and pulse duration but laser (dye) handling and compactness/ruggedness issues have to be addressed.

PHASE I: Investigate enabling technologies and component designs that are capable of providing multi-wavelength outputs at high energy per pulse in the vis/nir band. Consider trade offs of diode pumping vs flashlamp, multi-heads vs tunable sources, size, weight and cost and investigate the use of fiber delivery to provide a more flexible design. Use trade-off study to provide detail prototype designs to guide the Phase II activity. Conduct proof of principle experiments.

PHASE II: Utilize the findings established in Phase I to develop, demonstrate, and deliver a laboratory brassboard that meets performance specification outlined above. A design effort must demonstrate that the enabling technology/source can be packaged in a small package (2 cu ft).

PHASE III: An anticipated AIEWS P3I around FY05 would require such sources for field applications. Also other military, space and environmental applications such as long range differential absorption lidars, flash illumination, require high energy sources in this spectral range. There are also medical applications that can utilize these types of sources.

COMMERCIAL POTENTIAL: Many applications in medicine require short pulses to deliver significant energy (hundreds of millijoules) in a sub-microsecond time frame while simultaneously being delivered endoscopically to the site via a small fiber optic. Free-running lasers are not efficacious and Q-switched/modelocked lasers damage the fiber optics. A laser delivering light in the 0.1-10 microsecond range would be commericalizable very early after its development. Applications such as laser thrombolysis, glaucoma treatment, laser lithotripsy, and certain wavelength-sensitive ablative procedures are based on a short laser pulse creating a rapid thermal disturbance and consequence mechanical interaction with the tissue. If this laser technology were available in a robust, compact package it would have significant economic and social impact. This laser would also be a viable source for a lidar system.

KEYWORDS: Laser, Visible, Near-Infrared, Dye Laser, Multi-Line, Long Pulse

N02-059 TITLE: Innovative Sensor Technologies for In-Situ Air-Sea Sampling Under High Wind Conditions

TECHNOLOGY AREAS: Sensors, Battlespace

OBJECTIVE: Improve cost, survivability, and accuracy of in-situ oceanographic sensors to enable accurate, cost-effective, measurements of environmental parameters under extreme (very high and very low) wind conditions. Of particular importance is the development of sensors that can directly measure the momentum, heat, and moisture fluxes including bubble and spray contributions under these conditions.

DESCRIPTION: Under high winds (20 to 60 m/s), environmental conditions within the wave boundary layer prevent use of conventional in situ instrumentation. Applicable sensor technologies typically used in more benign conditions are described in References (1) and (2). Current platform, buoy and autonomous vehicle technologies and sensors are inadequate for the highly turbulent environment in the ocean under high winds. In the atmosphere, these extremes include stress and bending of instrumentation from wind and wave action, heavy salt deposition, heavy precipitation and/or sea spray. Equipment is also generally inaccessible during high wind events making direct monitoring and maintenance of sensors problematic. Innovative technologies are required for highly robust, reliable sensors which will be able to accurately measure critical flux parameters under high wind conditions. Acceptable solutions include ruggedized versions of proven instrumentation, local (non-space) remote sensors, or entirely new technologies. Instruments can be designed for autonomous operations from any stationary or mobile platform or bouy and may be either air, sea or self-deployed.

PHASE I: The contractor will demonstrate the feasibility of the proposed sensor technology through design and/or proof-of-concept demonstrations including description of parameter to be measured and instrument sensitivity. The contractor is expected to build on this technology base and expand its capabilities to include high sea state conditions.

PHASE II: The contractor will design, construct, test, demonstrate and document a prototype of the new technology, including performance specifications and estimated production cost. The contractor will interact with ONR in identifying specific applications for tests and demonstrations.

PHASE III: Sensors are expected to transition to international ocean observing systems to support research, routine monitoring of severe storms, and improve operational environmental prediction.

COMMERCIAL POTENTIAL: There is a large international research community supported by international government agencies, the insurance industry and the petroleum industry interested in understanding, measuring and monitoring extreme weather and ocean events.

REFERENCES:

1. Rapid Environmental Assessment, SACLANTCEN Conference Proceedings Series CP-44, E. Pouliquen, A.D. Kirwan, Jr., and R.T. Pearson, eds., NATO SACLANT Undersea Research Center, La Spezia, Italy, 1997.
2. Coupled Boundary Layers and Air-Sea Interaction Workshop Report. http://www.onr.navy.mil/oas/info/mm99/index.html

KEYWORDS: Oceanography, Instruments, Oceanic Flux Measurements, Environmental Sensing, High-Wind Environments

N02-060 TITLE: Compact, High Density Energy Storage Devices

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics

OBJECTIVE: Develop and demonstrate a compact, high density energy storage device that can be charged from a low rate energy generation source over a period of time and rapidly discharged to provide energy for high power pulsed applications or for short term demands for energy that are greater than that which could be provided by the low rate energy generation source associated with the system. The storage device must be capable of unattended (autonomous)

operation for periods of up to several weeks, be capable of being packaged for mounting within a twenty-one inch diameter shell, have low parasitic losses (hotel loads), and be cost efficient in comparison with alternative methods of energy storage.

DESCRIPTION: The Navy has many applications that require high power inputs over short periods of time. Active sonar pulses, burst speed power for surface and submerged vehicles, and power for countermeasure devices are a few of the potential applications that may require this type of short duration, high pulsed power input. The continued development of electric ships and vehicles is likely to generate further requirements and uses for such devices. Providing the power directly from a prime source causes the source to be sized for the maximum requirements of the application even though these requirements may only be applicable for short periods. This has a negative impact on the vehicle or device housing the power source, causing it to be larger and more costly than is actually required to support the needs of the particular application. A cost efficient, compact, high energy density power storage device would allow use of a smaller prime power source to meet system needs for short time duration, high power applications. The immediate current need is for use in a deployable, long-endurance acoustic source. The present device makes use of high energy density capacitors to meet these needs. However they are relatively bulky and heavy for the desired application. The energy storage device must be capable of storing sufficient energy to enable discharges of at least 50 KW over a 10 second period while maintaining voltage at a sufficient level to ensure that there is no significant degradation in the performance of downstream electronics. The device must be capable of autonomous operation for at least 1500 cycles of 10 seconds each over period of at least 30 days. Parasitic and other losses must be kept to an absolute minimum to assist in maximizing the endurance of the device. Potential solutions include, but are not limited to, improved high energy density capacitors, flywheel storage devices etc.

Typical contemporary flywheels use composite rotors with roller element bearings and spin at speeds of 20k - 50k rpm. Flywheel systems with minimal containment housings (not man-rated) but including a vacuum system and power conditioning electronics exhibit useable specific energy values of 1.5 - 5 Whr/kg and specific power that can exceed 1000 W/kg [1]. Theoretically, flywheel system specific energy values exceeding 50 Whr/kg are possible with current composite material technology [1]. The primary current area of emphasis for improving the performance of flywheels is the application of magnetic bearings in place of roller element bearings for supporting the rotor. Magnetic bearings present the potential to operate at higher rotor speeds with lower frictional losses and with longer life [2]. The current state of the art of ultracapacitor technology is close in performance to contemporary flywheel systems with regard to specific power and slightly lower in terms of useable specific energy. Ultracapacitor cells that can be purchased today advertise specific energy numbers of approximately 3 Whr/kg [3]. After including power conditioning electronics and interconnects between cells, system specific energy values of 1 - 2.5 Whr/kg are quite feasible. One distinct advantage that ultracapacitor systems have over current flywheels is a higher reliability due to the solid state nature of the ultracapacitor energy storage medium. For the acoustic source program, current flywheel technology could support mission energy storage requirements in a 20-inch long by 21-inch diameter shell section, albeit with unsatisfactory reliability and life. The weight of a suitable flywheel system is projected to be approximately 220 lb. The ultracapacitor system, currently in use, has been packaged in a 28-inch length of 21-inch diameter shell and weighs 270 lb. Although larger and heavier than originally desired for the energy storage component, the ultracapacitor system has thus far demonstrated excellent reliability and ease of operation.

PHASE I: Develop an alternative compact high energy density power storage device. Provide a detailed design and analysis showing the potential performance of the proposed device. Provide a detailed estimate of the costs of producing both prototype units and production units in quantities of 100. Conduct component/materials tests as needed to verify the validity of the proposed concept.

PHASE II: Fabricate a full-scale energy storage device for use in a long endurance, deployable acoustic source. Conduct laboratory tests to demonstrate and validate its performance including energy storage and discharge, unattended operation, heat buildup and dissipation, and endurance. Upon successful laboratory demonstration provide a unit for integration and test in an actual acoustic source unit. Update estimates of production costs.

PHASE III: Demonstrate production feasibility. Provide units for additional acoustic sources. Examine alternative configurations for other Navy/Marine Corps applications. Construct and test additional prototype devices for alternative applications.

COMMERCIAL POTENTIAL: Commercial applications for such devices currently include backup power source for computer systems to bridge the period between commercial power outages and the availability of backup prime power. Future applications include use in electric vehicles to provide energy for burst maneuvering speeds and other short duration, high power needs.

REFERENCES:

1. M. E. Bowler, "Flywheel Energy Systems: Current Status and Future Prospects," Magnetic Material Producers Association Joint Users Conference, 22-23 September 1997.
2. J. D. Stienmier, S. C. Thielman, and B. C. Fabien, "Analysis and Control of a Flywheel Energy Storage System with a Hybrid Magnetic Bearing," Transactions of the ASME, Vol. 119, p 650 - 656, December 1997.
3. "PC2500 Ultracapacitor," PC2500 Product Information Data Sheet (2001), Power Cache (Maxwell Technologies), 9244 Balboa Avenue, San Diego, CA.

KEYWORDS: Power Source, Energy Storage, Capacitors, Flywheels, Batteries

N02-061 TITLE: Four Dimensional (4-D) Atmospheric Instrumentation

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop low-weight, low-power, and low-volume instruments/sensors/techniques to autonomously measure atmospheric parameters.

DESCRIPTION: Innovative sensors and measurement techniques are solicited to obtain meteorological (METOC) variables (e.g., physical, chemical, optical, geophysical) in 3-D space and time. The emphasis should be placed on (1) novel approaches and concepts for measuring a particular parameter coherently in 4-D, (2) observations which can be conducted as autonomously as possible (i.e. for independent operation on Remotely Piloted Aircraft (RPA), Autonomous Underwater Vehicles (AUV's), ships, buoys or with expendable instruments), (3) providing a significant reduction in instrument weight, volume and power without reducing fidelity or resolution as compared to current state-of-the-art devices, and (4) developing the next generation of low cost, potentially expendable instrumentation usable in both navy operational scenarios as well as in S & T environmental data collection. Examples of some of the types of instruments solicited include: instruments to measure aerosol properties, optical properties, the next generation of low cost METOC expendable instrumentation, or the accurate measurement of temperature, humidity, winds, and wave properties near the surface in extreme conditions. The term Expendable Instrumentation includes both one time usage as well as long time in situ usage and the sensors should be affordable if expendability is required but reusable if not. Included are instrumentation development efforts that would result in significant improvements in sensitivity or reliability and cost savings for existing expendable instrumentation, or would develop new expendable capabilities for measurements currently obtainable by other means (such as aerosol properties, scattering absorption and phase function, visibility, IR extinction, etc.). All platform deployment scenarios are included and expendables can be launched, dropped, drift, etc. Priority is given to devices that can lead to substantial improvements in ship self-defense, airstrike targeting and special operations, through improved battle space environmental knowledge.

PHASE I: Provide both an exact description of the parameter to be measured including accuracy and sensitivity along with the instrument design concept for achieving the measurement.

PHASE II: Produce a viable prototype system and demonstrate its ability to support field measurements from an appropriate platform.

PHASE III: Transition the technology to scientific use in the atmospheric, oceanographic or environmental monitoring research communities, and operational DOD systems.

COMMERCIAL POTENTIAL: New instruments can be used in a wide variety of commercial environmental monitoring systems.

REFERENCES:
1. Rapid Environmental Assessment, SACLANTCEN Conference Proceedings Series CP-44, E. Pouliquen, A.D. Kirwan, Jr., and R.T. Pearson, eds., NATO SACLANT Undersea Research Center, La Spezia, Italy, 1997.
2. Stankov, B.B., 1998, "Multisensor Retrieval of Atmospheric Properties," Bull. of the Amer. Met. Soc., Vol. 79, pp. 1835-1854.
3. Serafin, R.J. and Wilson, J.W., 2000, "Operational Weather Radar in the United States: Progress and Opportunity," Bull. of the Amer. Met. Soc., Vol. 81, pp. 501-518 (includes many additional references).

KEYWORDS: Meteorology, Oceanography, Instruments, Miniaturize, Automation, Expendable

N02-062 TITLE: Ocean Data Telemetry Microsat Link

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: To perform the system design and development of a low-cost space borne constellation of microsatellites to transmit commands and information and recover the stored oceanic and atmospheric data.

DESCRIPTION: Recent advances in telecommunications may be combined with new generations of low cost and light weight microsatellite or nanosatellite platforms to develop a global over-ocean data relay constellation. There is an international initiative underway to instrument the oceans with a variety of sensors on buoys, moorings, and in-situ floats and autonomous underwater vehicles (AUV's). At present there is no cost effective high or moderate data rate means for communicating with these sensors and collecting open ocean data in near real time. An architecture study is required to define a constellation of low-cost, light weight and nearly autonomous satellites to allow moderate or high band width communication with a variety of ocean sensing platforms. Some of these platforms will remain submerged for days or weeks and come to the surface for brief periods to be commanded, transmit their data and receive new instructions. This effort will involve the definition of requirements for satellite systems in coordination with ocean platform communication and power requirements and land-based communication systems. Long duration semi-autonomous satellite operation is needed. An innovative and cost effective means to provide individual satellites with power and thermal control, attitude control, position information and the ability to receive and store data and uplink/downlink commands. A key element of this effort is the selection of communication frequency since this will impact the size of antennas on both satellites and ocean sensors and have important implications for power requirements and battery life of the in-situ ocean sensors. Daily data throughput per ocean platform should exceed 50 kbits with transmit power below 0.1 Joule/bit. The challenge is to deliver a pioneering yet low-cost hardware system with a reasonable lifetime (~3 years), compatible with very low uplink power (0.5 watt or less) and existing ground receiving infrastructure. There are significant low-cost opportunities to launch microsats into low earth orbit using excess capacity on Arianne and soon with the upcoming U. S. Evolved Expendable Launch Vehicle (EELV) rockets.

PHASE I: Develop a feasibility concept of a coupled systems including a constellation of space-borne microsatellites, compatible in ocean transmission/receiving systems and a land-based data collection center. Emphasis here is to be placed on the microsatellite hardware system. Prepare a risk or cost-benefit analysis comparing the proposed designs with systems currently in use.

PHASE II: Complete preliminary design of an overall satellite communication architecture including proposed microsat/nanosat hardware and existing ground infrastructure. Develop detailed electrical and mechanical designs of satellite systems to meet Phase I objectives. Fabricate and test prototype satellite hardware to include environmental testing.

PHASE III: Fabricate, launch and test a prototype small satellite meeting the specifications defined in Phase I. Launch services will be arranged independently and related costs should not be included in the contract. Develop a production and implementation plan for the extension of the prototype with follow-on launches of the remaining satellites needed to complete the constellation.

COMMERCIAL POTENTIAL: There is a significant commercial application for this system. The public and private sector would likely employ such a system for a wide variety of autonomous remote monitoring applications involving safety and warning systems at sea and ashore. Commercial fisheries, cruise ship operators and educators from K-12 through graduate level, et al would benefit from remote environmental sensor data. However, the fundamental user remains the warfighter at sea; efficient employment of precise weapons systems depends on accurate, real time environmental indices.

REFERENCES:

1. National Oceanographic Partnership Program Report "Toward a U.S. Plan for an Integrated, Sustained Ocean Observing System", April 1999
2. National Oceanographic Partnership Program Ocean Research Advisory Panel Report "An Integrated Ocean Observing System: A Strategy for Implementing the First Steps of a U.S. Plan", December 1999

KEYWORDS: Data, Communication, Sensors, Ocean, Atmosphere, Data Distribution

N02-063 TITLE: Novel Methods for Real-time in situ Analysis of Lubricants, Coolants, Hydraulic Fluids, and Fuels for Condition Based Maintenance

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IC: PEO Surface Strike DD-21 Program

OBJECTIVE: Design, develop, and demonstrate an inexpensive novel, integrated sensor-diagnostic package to monitor the condition of fuels, lubricants, coolants or hydraulic fluids both in real-time as a device mounted on a fluid line or as a bench-top tool. We will consider systems that employ sensors and sensing strategies that have not been used. Novel spectroscopies, electrochemical methods, or other physical principles can be used. To the greatest extent possible, the package developed should reflect the condition of the machine to which it is attached as well as the condition of the fluid being monitored.

DESCRIPTION: Readiness, reliability, and the confidence that the equipment needed for any mission can complete the job is an obvious priority of any military commander. Thus, any tool or system that can ensure mission capability is of great interest. Over the past decade, it has become increasingly clear that the state of mechanical 'health' of a machine can be substantially assessed through knowledge of the condition of the lubricating oil, coolant or hydraulic fluid. In addition, low quality, old or sabotaged fuel can jeopardize a mission and must therefore be monitored. Wear particle analysis has been a long-standing practice to gauge the condition of gears and bearings in machines. In recent years, infrared spectroscopic analysis of lubricating oils and hydraulic fluids has been able to reveal not only the condition of the base stock and additives, but also to allow inference of machine condition even in the absence of particle analysis. There has also been considerable progress recently toward both the development of automated particle characterization and counting and toward automated in situ infrared spectroscopic oil analysis. Encouraged by the successes of these efforts, ONR is interested in pursuing additional development of sensors and associated (automated) analysis packages to sharpen substantially our ability to detect machine faults well in advance of catastrophic failure. In particular, we are interested in any chemical or physical technique based on the chemistry and physics of failure (to the extent these issues are known) that can yield a reliable signal of detrimental change in mechanical health. Robust sensors that allow in situ analysis of lubricants, hydraulic fluids and coolants, their additives, and, both soluble and suspended, wear debris may be good candidates for development. While it is very important to know the state of the fluid, we also are particularly interested in how the state of a lubricant, coolant, or hydraulic fluid reflects changes in the machine at points distant from the site of analysis. If the degradation of components of an oil additive package, for example, can be specifically connected with a wear condition or event, this information can be used in conjunction with existing condition based monitoring (CBM) systems to build a more complete picture of the overall state of the machine and to estimate mission completion (prognostics). While several groups are already actively developing infrared, Raman, and fluorescent spectroscopic methods for oil analysis, novel approaches using these methods would be considered. Combinations of techniques might also prove useful.

PHASE I: Identify the components of the fluid to be monitored and demonstrate a connection between changes in these components and machine condition; this is not to be a literature search. Develop the sensing package and demonstrate its capabilities--proof of concept. Any sensing capability should be able to detect changes or degradation of 10% or less of the substance being monitored. Work at this stage should readily yield a "brass-board" prototype.

PHASE II: Target specific platforms on which the fluid monitors will be attached. Develop a prototype that can actually be demonstrated on the target platform; the prototype should conform as closely as possible to a final dimension and performance expected in a commercially available device. Determine operating limitations. Carry out extensive testing to provide monitoring baselines.

PHASE III: Seek commercial support. Refine the device/system to meet conditions for robustness and reliability. Prepare the device/system for field testing and subsequent possible commercial production.

COMMERCIAL POTENTIAL: Condition based monitoring through lubricant, hydraulic fluid, and coolant sampling is an active area of investigation as both light and heavy industries seek to produce maintenance-free products. Warranty claims against automobile manufacturers, for example, are a substantial liability. Inexpensive, reliable condition monitoring is an active area of research and development in the interest of bringing down these costs.

REFERENCES:

1. 1998 Technology Showcase: JOAP International Condition Monitoring Conference, Proceedings of a Joint International Conference, 20-24 April 1998, Mobile, AL. G. R. Humphrey and R. W. Martin, eds.
2. 2000 Technology Showcase: JOAP International Condition Monitoring Conference, Proceedings of a Joint International Conference, 3-6 April 2000, Mobile, AL. G. R. Humphrey, R. W. Martin and T. A. Yarborough, eds.

KEYWORDS: Oil Analysis, Lubricants, Hydraulic Fluids, Coolants, Fuels, Machine Condition, Condition Based Maintenance

N02-064 TITLE: Advanced Energy Scavenging System for Condition-Based Maintenance

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop an intelligent miniature energy scavenging system for condition based maintenance applications. Requirements of the candidate system are that it must be able to reconfigure itself so as to maximize energy scavenging efficiency at all times and that it have energy storage capability. The unit should be powerful enough to excite a small sensor (such as a strain sensor, a LED or a magnetic coil) and activate readout electronics and transmit data (1 – 5 meters). Initial calculations suggest that the power requirement will be in the 1mW – 10mW.

DESCRIPTION: Inspection requirements for Naval structures (ships, submarines and aircraft for the detection of cracks, corrosion, and impact damage) and engine parts (for detection of cracks, oil condition, and temperature excursions) are labor-intensive and therefore very expensive. As a result of today's TOC-reduction initiatives, new inspection methodologies are required that minimize the need for man-in-the-loop. Condition Based Maintenance by Continuous Based Monitoring (CBM2) is one possible approach to solve this problem. This approach requires a network of various types of sensors interconnected through a network to a CPU that performs diagnostic and prognostic functions.

Due to the requirement for the network to be retrofittable into existing platforms and also due to possible inaccessibility to some critical areas in those platforms, it is desirable that the network operate in a wireless mode. As a result each sensor in the network should be self-sufficient. Technologies are required that scavenge energy from the environment to power each individual sensor in the network. Due to varying environmental conditions, operating conditions, system types and other unforeseen changes the scavenging system has to be capable to reconfigure itself for optimum scavenging efficiency.

PHASE I: During Phase I of the program the contractor will down-select one approach and demonstrate that it can

generate a minimum of 5mW of DC power and store up to 5J of energy for a specific system application. The contractor will also demonstrate how the sensor can optimize itself to varying external parameters (such as varying temperature, vibration or other environmental variable). By the end of Phase I the contractor will provide a concept for producing 10mW system.

PHASE II: During Phase II the contractor will miniaturize the system to a foot print area smaller that 1 inch2 and height smaller than ½ cm. The power and energy requirements will be increased to 5-10mW and 5-10J respectably. The contractor will also demonstrate how the sensor can optimize itself to varying external parameters. The scavenging element has to be reliable enough to last at least the lifetime of the system that is being monitoring under the system's typical operational conditions.

PHASE III: An energy scavenging system of this nature could be retrofitted to existing Navy systems or installed in future Navy platform (such as ships, submarines, jet fighters, helicopters) which have structural components, engines, transmission gear boxes and other components that require periodic inspections to ensure the lack of cracks, corrosion or any other structural or engine problem. Significant cost savings could be achieved by the installation of this system by performing maintenance at longer time intervals or only when the system indicates that it is required.

COMMERCIAL POTENTIAL: Commercial ship and aviation industries would benefit significantly from a system of this nature as well. Widespread fatigue damage, corrosion and engine maintenance have been determined to be a major source of problems for commercial ship and aviation systems.

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KEYWORDS: Energy Scavenging, CBM, Sensors, Health Monitoring.

N02-065 TITLE: Ultralight Periodic Cellular Metals for Marine Expeditionary Fighting Vehicles

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: MARCORP Systems Command: MEFFX

OBJECTIVE: Develop novel processing for structural metals offering greater than 75% weight reduction capability for future highly mobile, survivable Marine Corps fighting vehicles. These metals must have high strength- and stiffness-to-weight ratios, be inexpensive to fabricate in a variety of complex shapes, be joinable to other materials, and offer excellent behavior in high corrosion environments.

DESCRIPTION: Future Marine fighting vehicles must be highly transportable, maneuverable, capable of operating in a variety of harsh littoral and on-land environments, and must be deployable, employable, survivable and sustainable. In order to extend operational reach to protect US forces throughout the littoral battlespace, such vehicles must be light enough to be easily transportable and to enable the high maneuverability required to help maximize their survivability, as well as to provide a different tier of mobility as compared with conventional vehicles. Consequently, new classes of novel lightweight structural materials offering weight reductions greater than 75%, compared with current conventional alloys, must be developed. Potential classes of metals, which would satisfy such weight reduction opportunities, as well

as potential for enhancing survivability from shock, blast, and by thermal signature reduction, include cellular metals with periodic architectures. However, to be viable, inexpensive material/structure processing/manufacturing methods must be developed. These methods must be flexible, to allow a variety of complex structures, inexpensive, and use conventional fabrication machinery. Components and structures must be joinable to conventional components, as well as having superior corrosion resistance.

PHASE I: Demonstrate metallic materials/structures capable of reducing the weight of vehicle structures by at least 75%. The architecture/microstructure of such materials/structures should be tunable for maximum mechanical property advantages. Document mechanical properties.

PHASE II: Produce structural components similar to those likely to be used in future Marine fighting vehicles and document mechanical performance. Generate vehicle/component design options using such materials/structures.

PHASE III: Demonstrate large-scale manufacturability and develop an implementation plan for production and implementation into a Marine vehicle.

COMMERCIAL POTENTIAL: Commercial potential exists for light, fuel-efficient vehicles, jeeps, recreational off-road vehicles, etc.

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KEYWORDS: Metals, Ultralight, Cellular, Periodic, Vehicles, Structures

N02-066 TITLE: <u>Naval Device Applications of Relaxor Piezoelectric Single Crystals</u>

TECHNOLOGY AREAS: Materials/Processes, Electronics

OBJECTIVE: Devise and fabricate practical devices for Navy and civilian applications that exploit the extraordinary electromechanical properties (high coupling: 90-95 %; high strain: ~ 1 %) of single crystal relaxor piezoelectrics.

DESCRIPTION: Near the onset of 1997 came the discovery that single crystals of certain relaxor ferroelectric (lead magnesium niobate – lead titanate, and lead zinc niobate – lead titanate) materials exhibit extraordinary piezoelectric properties, namely, strains exceeding 1%, and electromechanical coupling exceeding 90% (compared to 0.1% and 70-75 %, respectively, in state-of-the-art piezoceramics). Concerted efforts to grow these materials in a variety of forms (bulk, multilayer, fibers, thin films, etc.) now yield materials in quantities, and at a price, suitable for device prototyping. This topic aims to exploit these enhanced electromechanical properties in practical devices. For example: in acoustic transducers, the high coupling leads to higher bandwidth (doubled to two octaves or more), while the high strain leads to higher source levels (more than an order of magnitude increase); actuators employing these materials are more efficient and compact; and sensors are smaller and more sensitive. While this topic is open to a broad range of applications, the proposed device should rely on the special properties of the relaxor piezocrystals. In describing the application, state what property of these crystals is being exploited and why this is essential to the success of the proposed application. A design—no matter how clever—that could be realized effectively with conventional materials is not responsive to the intent of this topic. A Navy application specialist endorsing the importance of the enhanced performance in the proposed device would be a big plus.

PHASE I: Design and show the feasibility of a practical device exploiting high-strain, high-coupling relaxor piezocrystals with a laboratory test.

PHASE II: Refine the design and show the performance enhancements of the proposed device with a brassboard prototype in a laboratory or (if possible) field environment.

PHASE III: Demonstrate the cost-effective manufacturability of the targeted device structure in quantities appropriate to defense and civilian markets.

COMMERCIAL POTENTIAL: Applications in the defense sector from Navy sonar, through Army rotorblade control, to Air Force airfoil shape control—all have analogs in the civilian sector. Other applications will have their primary impact in the civilian arena, including medical ultrasonics, active machine tool control, and vibration suppression in HVAC systems.

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KEYWORDS: Electromechanical Sensors and Actuators, Vibration Control, SONAR, Piezoelectrics, Lead Magnesium Niobate –Lead Titanate, and Lead Zinc Niobate–Lead Titanate.

N02-067 TITLE: Archival Knowledge for the Design, Manufacture and Visualization of a Set of Energetic Devices

TECHNOLOGY AREAS: Information Systems, Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO (W): PMA 201 - Conventional Strike Weapons

OBJECTIVE: Develop a methodology that allows designers to optimally, and in almost real time, configure, design and visualize future small energetic devices with defined functional requirements and constraints. This methodology will be based upon a database generated by synthesizing information acquired from engineering, design and manufacturing information of a large class of existing devices.

DESCRIPTION: Currently several thousand, approximately 3100, different cartridge and propellant actuated devices (CAD/PAD) are used in DoD. CADs and PADs release precise explosive or propellant energy to perform controlled work functions in aircrew escape, fire suppression and operational and emergency release systems. Applications include Deep Submergence Vehicles, missiles and unmanned aerial vehicles, but the majority are used in aircrew escape systems or other safety-of flight applications. Being man-rated, they require a high degree of reliability.

Each of these devices has associated with it a specified set of functional requirements and a corresponding set of physical constraints that it satisfies. Each CAD/PAD must fit a physical space, interface with other components (initiation lines, seat/aircraft attachment points), and meet a variety of performance parameters (desired thrust-action time, G loading, MDRC, input/output pressure, actuation force), over operational and storage temperature ranges, typically –65°F to 200°F, and altitudes. Associated with each device is a set of engineering drawings, some of which are in electronic form, manufacturing and assembly procedures, performance (test) data, and cost. Many of these devices can be grouped into families of devices based on such factors as amount and type of charge, physical size, method of ignition, and the like. For instance, CAD/PAD can be grouped into one of two categories:

- CADS: Electrically initiated devices, explosive/gas/laser/mechanically actuated devices, delay-actuated devices, linear explosive devices, and special applications.

- PADS: PAD items with a net explosive weight (NEW) less than 0.5 lb, PAD items with a NEW more than 0.5 lb, and rocket catapults (ROCATs).

The aggregation of engineering design and manufacturing information represented by all of these devices is very large. However, the vast majority of this information is fragmented and, for all practical purposes, inaccessible to the next team

that is to design the next device. Thus, new design teams tend to make decisions based on their intuition and individual experiences. This can lead to increases in a new device's development time and in a design that may be less than 'optimal.' A new design approach includes new risks. During the recent design of a new PAD, a new propellant system was proposed by the supplier and subsequently selected by the prime contractor. The design was fundamentally sound. Unfortunately, there was insufficient experience with that system, eventually resulting in production difficulties. The prime contractor switched to a propellant system with which they had more experience.

Examples of design considerations for CAD/PAD groupings include:

- CAD/PAD: Form, fit, function, systems integration, reliability, producibility, material selection, proper firing mechanism designs, electrical bridge wire/welding techniques, glass to metal seals, propellant selection/stability, pressure/environmental seals, ballistic modeling, margins of safety, Hazards of Electromagnetic Radiation to Ordnance (HERO)/Electrostatic Discharge (ESD) characteristics, operating/storage temperatures, service live assignments, cost, rework capability, and DEMIL.
- Linear explosives: bend radius restrictions, explosive fill, shape, backing material (lead, tin, or copper), and standoff distance (in system) to cut a specific material of "x" thickness.
- ROCATs: Given seat weight, pilot weight and Center of Gravity (CG) range, and G limits, calculate the most desirable catapult-thrust combination.
- Other PADS: Given thrust-action time, solve for motor basic design parameters (propellant, web geometry, and nozzle throat), and propellant casting tooling design. Given seat weight, pilot weight and CG range, and G limits, assure design is compatible with system limits.
- It is proposed to develop a methodology to assist a design team of users of the devices to arrive at one or more candidate device configurations after being informed of the new device's functional requirements and its physical and cost constraints. We envision a system whose reasoning is based on a synthesis or distillation of the majority of these device designs done to date. The synthesized information then becomes the system's database. The system would then be able to quickly generate and evaluate a large number of possible configurations taken from the database.
- After the evaluation the system presents to the design team a set of feasible design alternatives. For example, what propellant or pyrotechnic delay formulations are best suited to the physical envelope, performance characteristics and temperature range. The presentation of the design alternatives might be in graphical form. Some type of ranking scheme of the design alternatives is also desirable. In addition, the system should be able to be continually and automatically updated after any new design is selected or created. Lastly, preliminary engineering drawings of the selected design must be able to be directly created and displayed.

PHASE I: Develop methodology that would allow users to design future devices using a limited set of data distilled from devices similar to existing cartridge and propellant actuated devices. Using a prototype example show how candidate devices may be designed and visualized.

PHASE II: Generate a complete program using most of the data from existing cartridge and propellant actuated devices to form the database. Incorporate the necessary design and manufacturing rules to extract new designs based upon new functional requirements and constraints. The designer should be able to view and interactively modify designs in a virtual environment.

PHASE III: Use the complete program and its databases to design a new device subject to functional requirements and constraints defined in consultation with the tri-Service CAD/PAD office at Indian Head, Maryland.

COMMMERCIAL POTENTIAL: The methodology developed here can be used to generate design and manufacturing rules for classes of devices that have a large amount of commonality. This is tantamount to creating a smart catalogue for a family of different devices useful for upgrading or effecting new designs in the military and the commercial world.

KEYWORDS: Cartridge Actuated Devices (CAD), Propellant Actuated Devices (PAD), Engineering Drawings, Virtual Environment

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4. NAVAIR 11-100-1.1 "Technical Manual for Cartridge and Propellant Actuated Devices"

N02-068 TITLE: Miniature, Conformal, Waterproof Shear Stress Sensor Array

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: PEO-SUB - Virginia and Seawolf Classes; PMS 450; NAVSEA 93R; DD-21

OBJECTIVE: Develop and demonstrate a miniature, conformal, waterproof shear stress sensor array that: enables high-sensitivity and high-resolution measurements; can be easily mounted on naval (submersible and surface platforms) and marine vehicles; and is capable of operation in freshwater or saltwater at speeds up to 20 knots (34 ft/s) and at depths up to 500 ft.

DESCRIPTION: The performance (powering and maneuvering) of naval and marine vehicles, including surface ships and submersibles (submarines UUVs and torpedoes, is greatly influenced by the surface flow separation and drag. In order to properly characterize and control these flow phenomena, we need to be able to measure shear stress accurately and reliably. There are several methods of shear stress measurements in aerodynamic applications (thermal and optical), but none of them can be used for naval and marine applications primarily because of a harsh operational environment in water and at depth. Traditional thermal sensors (hot film or hot wire) and more recent optical sensors are too sensitive to pressure and other parameters unique to water environment, such as fouling. Waterproofing is a major engineering issue that need to be resolved for these sensors for marine applications. The need to determine separation regions for model-scale vehicles requires that arrays (rings) of sensors be deployed at various axial locations along the vehicle. For applications to submerged vehicles, all signal processing equipment for the sensor array will be required to be positioned within the flooded vehicle; therefore, signal processing modules must be miniaturized, waterproofed, resistant to EMI and have minimal power requirements. For separation region detection, a scheme using relative measurements from the sensor array may allow the sensors to be operated uncalibrated. However, fundamental shear stress measurements will also be required; therefore, the sensors must also be capable of calibration to measure shear stress magnitude and direction. The sensor size (excluding processing electronics) must be no larger than 1 cm2. The sensors must be calibrated and capable of point measurements of shear stress magnitude and direction. The sensors must be capable of integration into an array for the simultaneous measurement of shear stress at many points. The surface ship and underwater vehicles have curved surfaces. In particular, submerged vehicles (e.g. submarine, UUV, and torpedo) have the typical shape of a prolate spheroid or circular cylindrical sections. Therefore, the sensors must be able to conform to the curvature of the body and must not disturb the boundary layer. A methodology for the use of the sensor array to determine separation points and lines and to determine drag must be developed. The initial goal is to deploy the sensors on a free-running submarine model; this will require miniaturization of signal processing modules for each sensor. Eventually, the sensors will be used for large- and full-scale surface ships, submarines, UUVs, and torpedoes. Both direct (floating element) and indirect (optical, thermal, etc.) measurement techniques will be considered. However, priority will be given to concepts that would deliver a compact power distribution system that will be effective and robust for sensors at various depths in water with its concomitant higher (than air) Prandtl number. By deploying the system on a free-running submarine model, the most challenging design requirements can be tested and validated. Support for Phase II tests using the Naval Surface Warfare Center, Carderock Division (NSWCCD) Radio Controlled Model (RCM) must be provided by a non-SBIR government program; requirements for planning such support will be presented at the Phase I kick-off meeting. The maximum instrumentation power consumption for their free-running model is 250 watts at 33-24 volts DC. The maximum size of the processing electronics (non-waterproofed) is 30" x 6" x 10". The maximum weight is 100 pounds. The hulls are free flooding hulls made of ¼" fiberglass – so the instruments will have to be waterproofed from the sensor to the processing electronics -- funds for testing at NSWCCD must be provided from another (non-SBIR) funding source. Transition to larger scale surface ships and submarine vehicles is

anticipated as a result of a successful demonstration.

PHASE I: Develop a miniaturized waterproofed sensor array (3 or 4 sensors) for operation in water and calibrate each sensor by placing it in a known shear stress field, or by using an independent transducer (such as a Preston tube, etc). Demonstrate that the array can detect separation. Develop a plan for miniaturization of processing electronics.

PHASE II: Miniaturize the processing electronics and extend the sensor array. Demonstrate the integrated system on a captive submarine model in quasi-steady conditions at speeds up to 5 kn (8.5 ft/s). Develop plans to transition the system to a free-running submarine model.

PHASE III: Transition the system to a free running submarine model (the RCM) and demonstrate detection of separation regions and measurement of shear stress at speeds up to 10 kn (17 ft/s), and to the LSV (Large Scale Vehicles), a large-scale autonomous submarine model, at speeds up to 20 knots (34 ft/s) with depth up to 500 ft.

COMMERCIAL POTENTIAL: The design of marine vehicles relies on a knowledge of the normal and tangential forces and moments exerted by the fluid on the vehicle during operation. The ability to measure shear stress simultaneously at many points, and thus drag, and to detect separation regions on a maneuvering vehicle provides needed data for comparison with computational fluid dynamics (CFD) analyses and for the development and assessment of current and future designs. There is a large market for both military and commercial applications of the solicited system.

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KEYWORDS: Shear Stress, Frictional Drag, Sensor, Array, Flow Separation, Measurement

N02-069 TITLE: Simplified Analytical Procedure for Prediction of Fracture Damage in Composite Structures

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IC: PEO Surface Strike DD-21 Program

OBJECTIVE: Develop a personal computer based analysis method for determining the initiation of damage in composite structural joints.

DESCRIPTION: The most critical and time consuming task of designing a composite structure is the detailed design and analysis of the joints. The typical design process consists of performing a global finite element analysis of the entire structure to obtain the forces induced at each joint location. This analysis is then followed by detailed finite element analysis of each joint. Current commercially available finite element codes such as NASTRAN and ABAQUS are well suited for the task of global analysis. They are also capable of the more complicated job of failure prediction of detailed joint models. However, the development of the joint model and assessment of the results is often extremely time consuming. One reason for this tediousness is that typical failure modes in standard composite joints involve either disbonds or delaminations through the thickness of the laminated plate structure. The prediction of these types of failure are more closely associated with the initiation and propagation of embedded cracks or flaws, than with in-plane stresses. Typical finite element assessment of these cracks require a high mesh density to accurately model the laminae and/or adhesive bond layers as well as some type of representation and monitoring of the crack size. These two features are what make the finite element method time intensive. Analytical methods that bypass the extensive input required for detailed finite element analyses are needed. These methods should result in a computer-based analytical solution that is applicable to a wide range of structural joint configurations. The focus should be on interlaminar failures such as debonds or delaminations. Two parameters used to assess the initiation or propagation of debonds or delaminations are the strain energy release rate (SERR) and interlaminar stresses. The purpose of this solicitation is to identify, develop

and implement analyses methods into a generic computer program that can quickly, accurately and with a minimum amount of input, determine the critical SERR and interlaminar stresses for a wide range of structural joint configurations.

PHASE I: Develop and/or demonstrate a generic analytical methodology that is capable of predicting interlaminar failures for a wide range of composite structural joint configurations.

PHASE II: Experimentally validate the analytical method developed in Phase I through a series of structural component tests that are representative of potential Navy composite structures. Implement the analytical method into a personal computer based software program.

PHASE III: Refine the computer program developed in Phase II to be useable by government or Industry engineers. Develop a users guide for the program that covers all theory and includes numerous examples that are relevant to Navy structures.

COMMERCIAL POTENTIAL: Composite structural analysis methods that have the capability to provide rapid analysis and design iterations reduce the time and engineering expense required during the design, testing and life cycle structural assessment of any design program. This includes current Navy ship design programs, as well as commercial programs in the aerospace and marine industries.

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KEYWORDS: Composites, Failure, Delamination, Analysis, Joints, Computer

N02-070 TITLE: <u>Methods for Monitoring Biodegradation of Pollutants in Estuarine Sediments</u>

TECHNOLOGY AREAS: Chemical/Bio Defense, Materials/Processes

OBJECTIVE: To develop site characterization tools and methods for demonstrating natural attenuation or biological degradation of organic pollutants in marine sediments.

DESCRIPTION: The Navy and DOD have numerous sites where contaminated sediments are present. Present treatment strategies include dredging, capping, or in situ, natural attenuation. It is this last approach which may yield the most cost-effective and operationally least disruptive approach for the Navy and DOD to comply with environmental regulations. Academic research supported over the past several years by ONR and other agencies suggests that: (1) microbial degradation of specific organic contaminants occurs in estuarine sediment samples and can be accelerated via laboratory enrichment of the organisms present at a site; (2)chemical signatures of microbial degradation may be used as "biomarkers" documenting these processes; and (3) sediment geochemistry and co-contaminants such as metals influence the extent and rate of contaminant degradation by microorganisms. However, documenting natural attenuation of organic contaminants such as 2-3 ring PAH's, selected PCB's, and fuel hydrocarbons as an approach that is protective of the environment still faces significant challenges before regulatory acceptance. What is required is development of appropriate bioanalytical tools which will aid in determining the site-specific efficacy (as well as limitations) of intrinsic

bioremediation as a alternative sediment management strategy. To achieve this goal it is necessary to establish that in situ bacterial communities capable of metabolizing site contaminants are present, active, and their in situ biodegradation rate can be projected. Biodegradation rates would then need to be compared with rates of contaminant transport (groundwater intrusion, sediment resuspension, contaminant burial, tidal effects) to form predictive models for natural attenuation. Desired outcomes of this effort may be: improved fate and transport models that take into account the role of biodegradation; development of gene-based sensors (for assessing the microbial community structure or presence of specific genes linked to contaminant degradation) and/or methods for determining site-specific rates and predicted extent of biotic/abiotic degradation.

PHASE I: Conduct lab-scale studies using contaminated estuarine sediments to develop and test methods for assessing microbial degradation of organic contaminants (PAHs, PCBs or fuel hydrocarbons). Develop methods to (1) correlate microbial presence to the observed degradation and (2) assess impact of grazers on bacterial activity.

PHASE II: Demonstrate in situ biodegradation of organic contaminants (PAHs, PCB's or fuel hydrocarbons) at an estuarine field site. Develop and demonstrate utility of analytical methods using genetic and/or biochemical markers to (1) assess site potential for biodegradation and (2) estimate rates of degradation in situ. Develop or expand existing sediment contaminant fate and transport models to include biodegradative processes.

PHASE III: Demonstrate feasibility of site characterization tools for documenting biodegradation of organic pollutants in marine sediments. Develop implementation plan for regulatory acceptance and approval. Participate in Naval Facilities Engineering Services Center "Remedial Innovative Technologies Seminars" to inform Environmental Restoration/Installation Restoration managers of new methodologies.

COMMERCIAL POTENTIAL: Current costs for characterizing, treating and monitoring Navy's contaminated sediments is estimated at >$500M for 110 sites; nationwide estimates for non-military sites are comparable if not higher. EPA estimates (1998) that fully 10% of the nations sediments are contaminated (1.2B yd3) and have identified 96 watersheds where contamination is significant enough to require management (dredging, capping). Navy (and other DOD), as well as industrial siteowners contract with private environmental contractor firms to collect site data, perform cost-benefit analyses of available treatment scenarios, negotiate with regulators, and perform monitoring of contaminated sediments.

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KEYWORDS: Biodegradation, Polluted Sediments, Polycyclic Aromatic Hydrocarbons, Polychlorinated Biphenyls, Hydrocarbons, Estuarine Systems.

N02-071 TITLE: Biology-Inspired Propulsion

TECHNOLOGY AREAS: Materials/Processes, Weapons

OBJECTIVE: A small to intermediate scale implementation of recently discovered unsteady lift enhancement mechanisms of small flying insects in to a tactical scale vehicle propulsor is desired to determine the feasibility of a lowering of rotational speed while maintaining thrust, as well as a net reduction of radiated noise after accounting for any penalty, any Reynolds number effects and robustness during vehicle life.

DESCRIPTION: According to conventional steady state aerodynamics, small insects like fruit fly should not be able to fly. Yet they do. Recently, biologists in Cambridge (UK) and UC Berkeley have discovered that, such insects resort to three additional unsteady lift enhancement mechanisms: delayed stall, rotational lift and wake capture. Out of these, delay of stall due to a leading edge vortex, and the resulting feasibility of highly loaded blades due to their very high angles of attack, is the most likely candidate for transition into existing engineering products. With advances in materials, control and computational technologies, it is desirable to know if this time-dependent mechanism can be incorporated into propulsor blade design to enhance the lift they generate. A payoff of such enhancement would be that

the same thrust would be generated at a lower rotational speed (RPM). Such a reduction of RPM could lead to an important reduction of radiated noise. It is also desirable to know what Reynolds number effects are involved in the generation and retention of a leading edge vortex for lift enhancement. While some aircraft designs having delta or canard wings use leading edge vortex very effectively for lift enhancement and the lift force theories are well known, the bridging of the wide Reynolds number range with small insects and application in water, need convincing demonstration. It is also necessary to demonstrate that the radiated noise penalty due to the generation of unsteady vortices, if any, still leaves a net benefit in quietness. Broadly speaking, the lift enhancement mechanisms need to be incorporated onto existing propulsors with minimal overall changes. Propulsor design tools need to be modified to account for unsteady mechanisms. Hydrodynamic and acoustic computational and experimental approaches are needed to develop a knowledge base for design.

PHASE I: Demonstrate via computational and experimental approaches on a small simple propulsor configuration that a leading-edge vortex can be generated and retained on a blade, resulting in enhanced lift. Work with reasonably practical advance ratio. A low Reynolds number initial effort is acceptable. Net changes in radiated noise would have to be estimated. Estimates from structural analysis of noise reduction, stemming from vibration reduction due to a RPM reduction, are also desirable.

PHASE II: Select a practical propulsor configuration for concept demonstration in water tunnel and anechoic chamber. Carry out computational design. Fabricate propulsor and carry out hydrodynamic thrust, drag and radiated noise measurements. Generate knowledge base for scaled-up design.

PHASE III: Conduct Weapons Analysis to determine the effect of noise reduction on torpedo homing effectiveness. Fleet demonstration of retrofitted torpedoes is also envisioned. Both Navy and commercial/industrial sectors are expected to be interested in this technology, if demonstrated, because of the military value of silencing and also the general consumer interest in quieting, and wear and tear reduction due to lower RPM. The generic nature of the technology and the wide prevalence of liquid pumps requiring quieting points to a wide Navy and industrial market.

COMMERCIAL POTENTIAL: Commercial and recreational boat propulsors and any industrial liquid pump would be the initial target for the application of Bioprop quieting technology. Larger scale vehicles would benefit if the technology is extendable to larger props and higher Reynolds numbers.

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1. Ellington, C. P. 1984 Philosophical Transactions of the Royal Society of London Series B, Vol. 305, pp. 79-113.
2. Dickinson, M. H., Lehmann, F. & Sane, S. P. 1999 Science, Vol. 284, pp. 1954-1960.
3. Bandyopadhyay, P. R. 2001Stability & Maneuverability, Annual Meeting of the Society of Integrative and Comparative Biology, 3-7 Jan. 2001, Chicago, IL, pp. 1-11.

KEYWORDS: Biomimetics, Vortex Lift, Radiated Noise, Propulsor, Torpedo, Demonstration

N02-072 TITLE: Legacy System Integrated Multimodal User Interface

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop and demonstrate multimodal decision support technology (speech, touch-enabled displays, gesture, map interactions) that is compatible with legacy paper-based systems. Employ existing tools such as Quickset and Rasa to collect performance data and develop metrics for digitally supported command and control decision making. Document reduced workload, manning, training required and improved effectiveness as a result of multimodal digital support. Demonstrate joint digital/paper-based system operation during product transition.

DESCRIPTION: A significant problem with the introduction of digital decision support systems and new technology in general is lack of trust in the performance of the new system. Experienced operators of systems, particularly during times of stress or short reaction time, often fall back to the use of legacy systems. This effort proposes the technology to allow both systems to work in parallel during a transition period in order to ease the transition and build trust in the new

system. The proposed digital support systems will use natural operator interface methods such as speech, gesture, sketching and coordination over map surfaces to aid the transition of non-computerized command and control environments to digital interfaces. This parallel processing-based transition will be based on DARPA developed tools Rasa and Quickset.

Rasa is a computer augmented environment for military command and control. Rasa augments the commander's primary tools for commanding ground forces, a paper map, pen, and post-it notes.
Officers choose paper tools for a variety of reasons:
* It has extremely high resolution compared to computer displays.
* It is malleable--it can be written on, cut in half, and thrown away.
* It is lightweight.
* It is portable and can be folded up and carried away.
* Finally, it is immune to the kinds of failures typically associated with computing systems.

With Rasa, users employ familiar tools and procedures, which in turn create automatic couplings between the physical objects (post-it notes and maps) and their counterparts in the digital world, allowing the users to manipulate their chosen paper artifacts, and consequently control digital objects in their chosen command and control systems.

QuickSet is an agent-based, wireless, collaborative, multimodal system that enables multiple users to create and control military simulations. Using speech and gesture, users position entities and give them behavior. QuickSet scales from wearable to wall-sized (e.g., LiveBoard) implementations, and has been used for large scale exercise initialization and logistics planning.

PHASE I: Identify an operations-based experimental environment and design a data-collection experiment. Collect speech, gesture and other interface data. Provide a report to assess compatibility with existing digital delivery systems (GCCS). Assess the feasibility of integration with legacy system.

PHASE II: Develop a concept of operation for demonstration of the proposed multimodal capability. Evaluate supporting hardware to include handheld, wearable, portable and wall map surface devices. Test multimodal capability in various environments and tempos. Collect data on workload, training requirements and effectiveness of system operation.

PHASE III: Deliver prototype multimodal system to include associated hardware, legacy systems integration software and training plan to implement system.

COMMERCIAL POTENTIAL: Similar resistance to transition to digital systems exists in many commercial and industrial situations. This product could also provide improved efficiency with reduced manpower and training.

REFERENCES:

1. Multimodal Interaction for Distributed Applications, Proceedings of the Fifth ACM International Multimedia Conference, 1997. Cohen, P.R., Johnson, M, McGee, D.
2. Is Paper Safer? The Role of Flight Strips in Traffic Control, Mackay, W.E., ACM Transactions on Human Computer Interaction, 1999.

KEYWORDS: Decision Support, Multimodal Interaction, Human Systems

N02-073 TITLE: Mast-mounted In-Port Video Surveillance System

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Enable improved force protection through passive, vision-based omni-directional detection, identification and tracking of pier-side vehicles and personnel as well as small craft operating in and around the operating vicinity of ships in-port.

DESCRIPTION: The Cole incident highlighted the need for robust force protection while operating in foreign high traffic harbor and port areas. Of particular interest are passive systems for improving the situational awareness of ship's personnel during in-port and harbor watch operations. During these operations, small craft traffic poses a significant risk. Land-based surveillance systems are usually not available or unreliable and active surveillance, such as radar and airborne sensing, would be considered intrusive. Watchstanders require a continuous, omni-directional surveillance capability to maintain optimum situational awareness. The desired system would detect, identify and localize small craft in relation to the ship. Accurate mapping and tracking to the ship's location on a contact grid combined with real-time image-based threat assessment would greatly improve force protection. Current technology such as multiple pan-tilt-zoom cameras tied into a multiple monitor display console are not robust enough for a maritime environment and would entail very sophisticated multiple camera views to provide continuous 360-degree coverage. Recent advances in optics, video technology and machine vision has enabled 360 degree cameras, and vision-based target tracking, that could utilize a single high resolution mast-based viewpoint. However, these systems need to achieve robust contact tracking within the visual clutter and obscuration of harbor traffic. Also, since such single viewpoint, 360-degree systems cover a wide area, achieving sufficient resolution in un-warped video images for identification and threat assessment is necessary. Threat identification is a key capability, and vision based recognition offers the kind of high fidelity easily understood information that Watchstanders require. Fusion with other sensing modalities (eg. passive acoustics) also needs to be examined. To minimize the footprint and cost of such a system, use of a single mast-mounted camera would provide the optimal viewpoint. The capability of visualizing (and tracking) persons in open craft at closer ranges and on docks could also be accomplished with such a system and would help identify and characterize possible threats.

PHASE I: Characterize the vision problem (resolution, ship motion, wave clutter, target range for a mast-mounted, ship borne EO/IR sensor monitoring system). Identify robust tracking approaches for video imagery of small craft and pier-side personnel and vehicles. Assess the feasibility of super-resolution in a single viewpoint, 360-degree camera imagery. Develop a strategy for identification of threat from imagery or fusion with other information (for example, acoustic or wave signature). Propose a panoramic video system with specific hardware and software components.

PHASE II: Develop a prototype system, and test on an in-port vessel. Validate the detection and tracking capability for small craft, with ground truth provided by GPS equipped target craft.

PHASE III: Design interface for providing information to ship Watchstanders. Possible solutions include placement of contacts on a 2D grid in relation to vessel. Integrate panoramic EO/IR imagery information with surface combatant contact management and targeting systems. Production engineering of system for installation on surface ships in conjunction with an OEM. Customers include PMS 440, NAVSEA 53 and NAVSEA 765.

COMMERCIAL POTENTIAL: The commercial potential is in the large security and surveillance industry (facility protection), in law enforcement, and in commercial port operations.

REFERENCES:

1. Proceedings: 1998 DARPA Image Understanding Workshop, Nov 20-23, Monterey, CA. Morgan Kaufmann Pub., ISBN: 1-55860-583-5.
2. 2000 Proceedings of the International Conference on Computer Vision.

KEYWORDS: Ship Protection, Video Surveillance, Panoramic Vision, EO/IR, Target Tracking; Motion Analysis

N02-074 TITLE: <u>Conversion of Supercritical Air Self-contained Breathing Apparatus (SCBA) for Diving Applications</u>

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Diving in contaminated water is a risk to the health of divers in both war and peacetime. The wearing of chemical/biological protective garments causes heat retention that can seriously impair the performance and safety of divers. The objective of this research program is to modify an existing cryogenic self-contained, positive pressure

breathing apparatus, integrated with a whole body cooling system, for use in diving. This system, currently designed for use in air, can potentially obviate the severe thermal insult to Navy and Marine divers in hot, contaminated waters.

DESCRIPTION: The novel feature of the system is its use of supercritical air to power a positive pressure breathing gas supply integrated with a whole body cooling system. The use of air in a supercritical state obviates problems of oxygen enrichment common to liquid air systems, and provides position independence since the coolant/gas supply is a single-phase fluid. The technology has been demonstrated to both NASA and the U.S. Navy, and units based on the technology have been informally dived by NASA. This work will adapt the unit to diving, and ensure the unit remains responsive to the metabolic requirements of a diver under high heat load diving conditions.

PHASE I: Conduct engineering analyses to determine the impact of seawater compatible materials on heat transfer and overall system performance. Assess through physiological and engineering analyses the impact of heat loads from ambient water on the unit's ability to respond to heat generated by a diver in response to metabolic demands. Assess heat exchange characteristics and overall system performance under the elevated pressure and gas density conditions encountered in diving.

PHASE II: Make material and insulation changes to the system and test the reliability of the previous engineering analyses under warm water (up to 105° F) in unmanned, 1 ATM laboratory conditions. Verify salt-water tolerance of the unit through salt water immersion testing.

PHASE III: Pressure testing during manned diving in seawater at the Naval Experimental Diving Unit as a verification of the appropriateness of design and material changes.

COMMERCIAL POTENTIAL: Commercial divers have the same requirements to dive in hot contaminated environments, as does the U.S. Navy. The ability to keep a diver safely and effectively on the job is a bottom line concern for the commercial diving industry.

REFERENCES:

1. Gier, H. Self contained, cryogenic mixed gas single-phase storage and delivery system and method for body cooling, gas conditioning and utilization. U.S. Patent no. 5,709,203, Jan. 20, 1998.
2. Gier, H., RL Jetley, Conditioning and loading apparatus for gas storage at cryogenic temperature and supercritical pressure. U.S. Patent no. 5,582,016, Dec 10, 1996.
3. Gier, H. Self contained, cryogenic mixed gas single-phase storage and delivery. U.S. Patent no. 6,089,226, Jul 18, 2000.
4. Doerr, D. Breathing apparatus stores cold supercritical air, disadvantages of liquid air packs are overcome. NASA Tech Briefs, 1999, 23:57-58.

KEYWORDS: Supercritical Air, Cryogenic Air, SCBA, Warm Water Diving, Contaminated Water Diving, Whole Body Cooling

N02-075 TITLE: Advanced Ship Motion and Air Wake Sensing and Prediction

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Develop state of the art algorithms that include wind and ocean effects to predict ship motion while also using advanced sensors to gather atmospheric and sea condition data to validate the algorithms.

DESCRIPTION: The task of safely and expeditiously recovering aircraft aboard aircraft carriers and other air capable ships is complicated by two main environmental factors: ship motion and air wake. The pitch, roll and heave of the ship contribute to missed arrestments (bolters) and hard landings and negatively affects both fixed wing and helicopter recoveries. On carriers, ship motion also causes the hook to ramp clearance and hook touchdown dispersion to vary to unsafe levels in higher sea states.

Ship motion has long been a goal of the US navy to promote a wider range of safe ship and aircraft operations. Efforts in the past have resulted in limited successes due to incomplete test data sets and the lack of the algorithms that consider up to 6 degrees of freedom. Neural Networks, Kalman filters and Fourier transforms that used up to 2 degrees of freedom have been used in the past to try and determine the dominant frequency and amplitudes of the ship motion with little success. Ship motion prediction studies in the past have used ship's gyroscopes as the primary data. This topic seeks to investigate the feasibility of acquiring other data to improve the prediction performance, such as wave heights/periods and undersea currents in front of the ship, and ambient wind speed and direction and whether that data can be effectively used for more accurate prediction and for a longer time period into the future. A time period of 6-15 seconds is required for the ship motion forecasting to be of use, with a 20-40 second goal for lull prediction. This study should investigate the upper bound on the prediction time and include motion forecasting and lull predictions methodologies that should be studied and applied with an emphasis on zero crossing errors instead of peak-to-peak errors. Other issues should include the effects of the coupling of energy between the multiple degrees of freedom and the non-homogeneous weight distribution of the ship.

A system that predicts ship motion could be used to adjust the aircraft's glideslope through inputs to the automatic carrier landing system or visual cues to the pilot, or determine lull periods for helicopter operations. This data will result in improved boarding rates (which contribute to improved sortie rate), improved landing gear life, and improved operational safety.

PHASE I: Conduct a feasibility study on ship motion prediction. Investigate various algorithmic approaches for prediction, perform a trade-off analysis, and determine optimum approach. Identify the atmospheric and wave/sea condition data that are important. Identify sensors, either off-the-shelf or requiring development, to gather the data. Determine functional requirements, including a requirement for prediction time into the future. Demonstrate chosen algorithm on simulated data.

PHASE II: Develop and demonstrate a system for ship motion prediction aboard an air capable ship. System should include the appropriate sensors for data collection.

PHASE III: Produce a system for installation aboard aircraft carriers and air capable ships. Integrate into automated landing systems and visual landing aids that operate on the ships.

COMMERCIAL POTENTIAL: A ship motion prediction system could have application for commercial vessels with active rudder control.

REFERENCE:
1. Systems Technology, Inc., Technical Report 1321-1 Entitled "Advanced Ship Motion Forecasting for Expanded Aviation Operations" May 28, 1996.

KEYWORDS: Ship Motion, Air Wake, Prediction Algorithms, Advanced Sensors

N02-076 TITLE: <u>Synthesis of Polyacetylene Curing Agents</u>

TECHNOLOGY AREAS: Materials/Processes, Weapons

OBJECTIVE: Synthesize, characterize, and scale-up sufficient quantities of reactive di- and triacetylenes to elucidate the structure activity relationships of these compounds with the mechanical properties of oligomeric azides cured into polymers by the formation of triazole linkages.

DESCRIPTION: Cast-curable oligomers, which include most of the binder materials used for propellants and explosives, are typically cured into rubbery materials by the reaction of a di- or polyisocyanate with the hydroxyl groups at the end of the oligomeric chains. This reaction allows the mixing of energetic oxidizers, fuels and other solid filler materials into a castable mixture without the evolution of water or gaseous byproducts and the solidification of the mixture into the shape of choice with sufficient structural properties to survive combustion processes. The facility of the

reaction, its absence of byproducts, and the vast array of chemical structures available in both the hydroxy-terminated binder material and the di- and polyisocyanate curing agents, ensure that a combination of oligomer and curative can easily be found that will impart satisfactory mechanical properties to the binder. The ceaseless search for higher performance in explosives and propellants has necessitated the investigation of new energetic ingredients whose chemistry is inimical to the urethane cure reaction. An effort has begun to explore the curing of azido-terminated oligomers with di- or polyacetylenes to form triazole rings linking the oligomers into a polymer network as a means of finding a more robust polymer cure mechanism which is not sensitive to the reactivity of these new energetic ingredients. Thus far, it has been shown that this cure, like the isocyanate/hydroxyl reaction, is facile, evolves no water or gaseous byproducts, and proceeds in the presence of energetic compounds, which absolutely prevent the curing of isocyanate/hydroxyl binder mixtures. The problem here is a lack of understanding of the structure activity relationships between various oligomers and acetyleneic cross-linking agents. Moreover, there is an insufficient supply of the necessary di- and polyacetylenic compounds to thoroughly evaluate this cure mechanism and to optimize the mechanical properties of the resultant polymeric material. At a 0.5% to 2% level in a 500-gm propellant mix, this reaction can consume up to 10-gm of acetylenic curative. At this point, such materials have been synthesized only on the gram scale in the laboratory. Synthesis of scaled-up quantities of such polyacetylenes (100 to 450-gm scale) and the preparation of a variety of such structures are needed to optimize the mechanical properties of propellant mixtures curable by the triazole cure reaction.

The following four compounds, 1,4-(dicyanodietheyl)bezene (1) dipropargyl terephthalate (2) tripropargyl mesitylate (3) dodecane-2,11-dione-1,12-dipropiolate (4) which can be used to cure, crosslink, and tailor the mechanical properties of triazole-cured azido prepolymers are required. The syntheses of these sample materials was completed at China Lake or in the chemical literature, and should be easily scaled, improved upon, and optimized. Having 100 to 450-gm batches of each of these compounds will allow mechanical property optimization of this new binder cure so that the binder may be fully competitive with urethane counterparts.

PHASE I: Synthesis, characterization and scale-up synthesis reactions for compounds 1-4. All except 1 are esterification reactions, while 1 uses a phosphine reagent.

PHASE II: Undertake process research and development studies to production quantities. Explore scope and limitations for this family of curatives and produce new compounds in quantity sufficient for propellant formulation evaluation.

PHASE III: Demonstrate producibility and develop an implementation plan for new production and replace via attrition of in-service tactical rocket motors. Work with existing propellant manufactures to transition new technology through patented position.

COMMERCIAL POTENTIAL: Traditional hydroxy-terminated conventional rubber properties can be accomplished if the hydroxy end-groups were substituted with azide moieties allowing for the formation of a triazole linkage. This would render unnecessary the use of the relatively toxic isocyanate compounds that are currently used as curatives and lower the hazards involved during polymer fabrication. The resultant triazole-cured rubbers should prove more robust in their response to aging, ultraviolet light and temperature conditions. The urethane/isocyanate cure market is in the hundreds of millions of pounds per year. This represents a significant potential market.

KEYWORDS: Propellant, Binder, Polymerization

N02-077 TITLE: <u>Elevation Data Generation using UAV Imagery</u>

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: To research and develop a feasibility concept for automated techniques that use high spatial resolution stereo Unmanned Aerial Vehicle (UAV) imagery to improve the resolution/accuracy of digital elevation data generated from lower resolution/accuracy imagery sources.

DESCRIPTION: The ability to generate accurate digital elevation models (DEM) has been an area of interest to users for

years. Presently, there are existing technologies capable of nominally producing these data sets to various levels of accuracy as defined under DEM product specifications. Emerging requirements, however, call for increasingly higher levels of DEM posting accuracy supporting, among others, targeting, mission planning, and collection management applications. This desire for more elevation detail poses a variety of challenges in that neither spaceborne data sources nor existing softcopy photogrammetric solutions have proven sufficiently robust in producing such improved DEMs reliably.

In considering alternative imagery sources, future UAVs will likely have absolute positioning capabilities of 10 cm and sensor pointing accuracy of 100 milliradians or less. When this positioning accuracy is coupled with the inherent high spatial resolution and multiple views the generation of highly accurate DEM patches should be feasible. To be generally useful, these detailed patches must be merged with, and used to improve, broader area DEMs generated from more traditional sources. In addition, the whole process must be highly automated and include accuracy estimates at each elevation posting position.

Thus, there is a need to investigate these alternative UAV imagery sources as compliments to existing spaceborne sensors for DEM generation, supporting the military applications mentioned above. Given the dynamics of UAV imagery, however, this will also require research of improved softcopy DEM generation capabilities that can utilize the strengths of both the spaceborne and UAV imagery sets jointly.

PHASE I: Research and develop an enhanced DEM generation software approach that will exploit accurate position and pointing information together using two or more images. Evaluate this technology in the context of high-resolution DEM generation to support military applications using spaceborne imagery together with multiple airborne (UAV or manned aircraft) images.

PHASE II: Prototype a software system that provides improved capabilities in DEM generation by using both airborne (UAV or manned aircraft) and spaceborne imagery sources.

PHASE III: Develop a complete software package including user documentation for use of the DEM generation system as a stand-alone application or as an embedded application within larger systems.

COMMERCIAL POTENTIAL: This software could be used by state and local agencies as well as the private sector for generation of high-resolution elevation data for variety of geo-spatial applications such as surveying, earth-resource management, planning, and monitoring. It also has great commercial potential for jointly exploiting airborne photogrammetry and the new generation of high-resolution commercial satellites in all of the areas where airborne photogrammetry is currently marketed. The ability to use UAV imagery will also be of great interest to local governments and US agencies as they seek lower-cost alternatives to rapid and repeated mapping.

REFERENCES:

1. "Three Dimensional Computer Vision - A Geometric Viewpoint", by Olivier Faugeras, The MIT Press, Cambridge, Mass, 1996.
2. "Quality Assessment of Object Location and Point Transfer Using Digital Image Correlation Techniques", Wolfgang Forstner, ISPRS XVth Congress, Rio de Janeiro, 1984.

KEYWORDS: Targeting, UAV, Softcopy Photogrammetry, Stereo Imagery, Multiple Images, Digital Elevation Data, Software.

N02-078 TITLE: Micro-Chip Laser Beam Switch for LADAR Transmitter Applications

TECHNOLOGY AREAS: Sensors, Electronics, Weapons

OBJECTIVE: To develop a high speed, high optical damage threshold, low optical loss, four output laser beam switch and its drive electronics for use in LADAR systems.

DESCRIPTION: The NAVY is developing a low cost, compact gimballess LADAR system that is based on microchip laser technology. A microchip laser is a compact diode pumped solid state laser and are usually Nd:YAG or doubled Nd:YAG. Micro-Chip Lasers typically run at average powers of 30 mW, up to 30 KHz pulse repetition frequency, 600 ps pulsewidths and TEM00 beam quality. This LADAR system will obtain angular resolution of targets by scanning the space sequentially with a high pulse repetition frequency laser. The majority of existing switches have switching times much longer than the tens of microseconds required for this application. Sequential transmission of laser pulses from one laser to four separate apertures can be done in variety of ways. Some examples are by using (1) diffractive optics, (2) pockels cell - polarizing beam splitter combination, and (3) e-o deflectors. Any electo-optical solution must be free of piezo-electric resonance. Any of these, and other, solutions are acceptable as long as the specifications for the physical size, laser damage threshold, and speed are met.

Specific Navy requirements for the laser beam switch are: 1) This device must be capable of large-scale production. 2) This device must be low cost. 3) The device must have low optical loss (less than 10 % attenuation). 4) The device must have average intensity optical damage threshold of 1 W/mm2 or better. 5) The device must be compact (less than 2 cubic inches). 6) The rise/fall time must be shorter than 10 ƒÝs. 7) The on state must be held for a minimum of 5 ƒÝs. 8) Must be capable of operating across the temperature range of ¡V40 C to +75 C.

Specific Navy requirements for the drive electronics are: 1) This device must be able to drive the deflector device to meet the specifications that are listed above. 2) The device must be compact. 4) This device must be programmable to allow the flexibility for modifying the temporal shape (gate delay and width) and repetition rate.

PHASE I: Develop a laser beam switch design and drive electronics design for sequential transmission of micro-chip laser pulses into four quadrants. Perform a feasibility study, which clearly demonstrates the functionality of the concept. Comparison of various possible solutions must be made. The study must include a thorough analysis of the noise, resonance, speed, and efficiency of the proposed concept as well as an experimental demonstration of the essential features of the concept.

PHASE II: The primary goal of Phase II is to demonstrate a working laser beam switch which is based on the concept developed during Phase I. The work will include developing the capability to manufacture the laser beam switch and its drive electronics and integrating the device with a microchip laser for use in LADAR systems. This phase will also include performance tests of the overall LADAR system.

PHASE III: Integrate the transmitter into a working LADAR system and demonstrate the performance enhancements in flight tests

COMMERCIAL POTENTIAL: The telecommunications industry requires fast all optical switches to improve the speed and reliability of fiber optic links.

KEYWORDS: Optical Switch, Electro-Optic Deflectors, Pockels Cell, Diffractive Optics

N02-079 TITLE: Flight/Hangar Deck Cleaner

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop and demonstrate a mobile low-pressure water-jet unit to clean nonskid coatings on the decks and hangar bays of air capable ships. The unit should be self contained, operate on available JP-5 jet fuel, have the capability

to filter and recycle water, separate oil from water when discharging, provide extended use between launches and recoveries, and have a cleaning capacity range required at rate of 10,000 sq ft per hour.

DESCRIPTION: Non-skid surfaces and materials are unable to last the duration of a full deployment, resulting in interrupted flight operations and reduced operational readiness. While underway, the flight and hangar decks need to be cleaned nightly to remove oil residue resulting from flight deck operations. Cleaning the flight deck is manpower intensive and results in a hazardous waste disposal problem.

An 03 May 2001 interview with the crew on onboard the USS Theodore Roosevelt (CVN 71) revealed the following:
- Current model does not meet requirements of thoroughly cleaning the non-skid surfaces within a reasonable timeframe. Crew is very dissatisfied with product
- Cleaning is done on a daily basis
- Nylon cleaning brushes contribute to erosion of non-skid surface
- No steam heat capability with spray hose and nozzle for thorough removal of oils
- Largest cleaning area – 55,476 sq ft, smallest cleaning area – 21,000 sq ft. Measurements do not include hangar bays. It takes approximately 50 people 2 hours to clean 55,000 sq ft (3-5 people per squadron/8 squadrons). Scrubbing, maintenance, spot cleaning and moving aircraft take place simultaneously

Detailed specifications and cost analysis for proposed unit can be provided upon request.

PHASE I: Develop and describe the characteristics of a prototype.

PHASE II: Identify characteristics of operating in routine and adverse environments; finalize design; build & test prototype.

PHASE III: Develop implementation strategy for new product.

COMMERCIAL POTENTIAL: Similar units are currently used in the private sector, i.e., used to clean construction sites and to clean & refresh ice skating rink surfaces.

KEYWORDS: Flight Deck Cleaner, Street Cleaner, Mobile Low Pressure Water Jet, Maintenance; Non-Skid

N02-080 TITLE: Vertical Flight Deck Operations Trainer

TECHNOLOGY AREAS: Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA-205 (Aviation Training Systems), PMA-299 Multi-Mission Helicopter.

OBJECTIVE: To create a training device that represents VSTOL and helicopter aircraft operations in takeoff and landing phases of operation on-board ship. The system will serve to train the Landing Signal Enlisted (LSE) and the Helicopter Control Officer (HCO) simultaneously, and therefore must respond to LSE hand gestures and/or LSE and HCO spoken commands, as well as instructor/operator inputs.

DESCRIPTION: The coordination and communication requirements between a pilot landing a helicopter on a small ship, and the shipboard personnel responsible for directing those ship-board landings leaves no margin for error. Today, the average LSE receives less than 60 seconds of live interaction with a helicopter during training. The time spent in LSE/HCO coordination is largely limited to shipboard operations. It is proposed that a training device be constructed that simulates a helicopter shipboard landings, a device that responds to hand signals of an LSE, and voice commands of the HCO and LSE. The device would also be of use for training emergency situations. Today the personnel involved in helicopter shipboard landings must learn first hand, on the job, how to appropriately respond to emergency situations. Such a simulation training device would also be of use to emergency personnel (fire, police, medical) who may be required to signal helicopter landings without any prior real or simulated training.

PHASE I: Provide a feasibility study which identifies the technologies available and develops a method to represent a generic VSTOL aircraft during operations (Model aircraft should be the H-60; the ship to model the deck should be a T-AFS) and which would respond to the hand signals and speech inputs of the LSE and HCO trainees. The visual system should minimize the problems of depth perception, viewing of the helicopter when overhead and distant estimation that can occur in simulated displays. The development of a hand (or wand) tracker would be required, and the system should allow the user to move about an open area of about ten by ten feet as necessary - yet still be able to track their signals and voice commands and respond appropriately. Additionally, the proposed method should be of a modular, open architecture design to facilitate upgrades and other aircraft types (V-22, Marine Corp JSF, civilian, foreign Helicopters, etc.).

PHASE II: Develop, test and operationally demonstrate the system formulated under the Phase I effort.

PHASE III: Produce the system demonstrated in Phase II for other training applications (foreign military, commercial, public safety).

COMMERCIAL POTENTIAL: There is significant commercial potential. The Navy's Helicopter Operations school currently trains helicopter landing signal personnel that support the commercial industries such as the logging, hospital, and police organizations. Training a variety of signal-persons in commercial settings, marketing of arm/hand trackers for other non-DoD applications.

REFERENCES:
1. Naval Warfare Publication Nos. NWP-42 and NWP-19.

KEYWORDS: Landing Signal Enlisted, Helicopter Control Officer, V-22, JSF, LSE, HCO, Helicopter

N02-081 TITLE: <u>Onboard HF Radar Ocean Current Mapping</u>

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Battlespace

OBJECTIVE: Develop a mobile high frequency (HF) radar system capable of mapping ocean surface currents from a moving ship. Assess the resolution, coverage, and accuracy of potential mobile system designs with respect to existing, shore-based systems.

DESCRIPTION: Operations in the littoral ocean are increasingly central to Navy and Marine Corp activities. Coastal ocean currents affect both the at-sea and ship-to-shore components of those activities. Strong currents, for example, may preclude diver and small-boat operations. They also control important processes such as the transport of sediments, hazardous materials, or drifting mines. Most importantly, coastal currents can be extremely variable in time a space in ways that cannot be predicted using available models or remote sensing techniques. As an example, coastal sea level fluctuations due to well-known tidal forcing can be predicted accurately nearly anywhere in the world. At the same time, tidal-period coastal currents cannot be predicted without local observations because sea level fluctuations interact with complex coastline bathymetry to produce highly variable current patterns. HF radar instruments have been developed within the research community that use signals backscattered from the ocean surface to map near-surface currents over ranges of 30 km to 200 km. Present systems utilize both long (~100m) phased array and compact (~3m) direction finding antenna configurations. In all cases, receive antennas must be located on the coast within several meters of a beach or coastal bluff. Existing systems also utilize monostatic transmit and receive geometry in which the transmitter and receiver are located together at the coastal site. Independent systems must be mounted in, at least, two locations so that radial current data from multiple sites can be combined to form vector maps of ocean current. The Navy has an operational need for Rapid Environmental Assessment (REA) in the littoral ocean. In this context, REA requirements point to the need to develop non-invasive, remote sensing techniques capable of mapping coastal ocean currents. These needs can be met by building HF radar systems capable of operating from slowly moving ships at sea. In many situations, access to a non-cooperative nation's coast to locate or support instrumentation is not an option. Data must be gathered from vessels underway and platforms located outside territorial coastal boundaries. Shipboard HF

radar instruments would also greatly expand mapping capabilities within the research and coastal management communities. Radiation of HF signals from a ship is undesirable, as it both serves to identify its presence and location for targeting and is a source of interference to the many shipboard HF communications systems. Therefore, in addition to developing HF radar receive antennas and processing software for at-sea use, this program in its later phases will seek to implement the algorithms required to operate HF radar systems with a bistatic geometry. i.e., with separate transmitter and receiver locations.

PHASE I: Feasibility study of the hardware and software requirements for creating a HF radar system that can be used from a moving ship. Emphasis should be on describing the accuracy of the velocity field as a function of ship motion, both translational and wave-induced. Simulations using realistic and accepted models for sea echo, noise, antenna patterns and their expected distortions from shipboard superstructure should be employed. Critical issues or high-risk elements should be identified and documented.

PHASE II: Build and test a prototype shipboard HF radar current mapping system capable of operating in monostatic or bistatic transmit and receive configurations. Testing should be accomplished using a research vessel large enough to simulate HF antenna distortions onboard naval vessels. The focus should be on moving receiver technology with either bistatic or monostatic transmitter configurations. The tests should include comparisons with in situ current sensors, such as moored current meters or drifters.

PHASE III: Requirements specifications for moving receiver HF radar ocean current mapping systems, including descriptions of receive and transmit hardware, antenna designs, and direction finding algorithms.

COMMERCIAL POTENTIAL: The commercial market for all HF radar ocean current mapping systems will be increased by successful completion of this project because greater deployment flexibility and greater spatial coverage will be available for both military and civilian applications.

REFERENCES:
1. Paduan, J.D., and H.C. Graber, 1997: Introduction to high frequency radar: Reality and myth. Oceanography, Vol. 10, pp. 36-39.
2. Barrick, D.E., M.W. Evans, and B.L. Weber, 1977: Ocean surface currents mapped by radar, Science, vol. 198, pp. 138-144.
3. Methods of Satellite Oceanography, Stewart, R.H., 1985, University of California Press, Berkeley.

KEYWORDS: Ocean Currents, Littoral Environment, HF Radar, Mapping Systems

N02-082 TITLE: Directional Acoustic Transponder

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop an underwater acoustic transponder that is capable of providing range and bearing from it to a host, where the host is a diver or an Unmanned Underwater Vehicle (UUV). Range and bearing can be provided to the host upon acoustic interrogation or at predetermined periodic intervals. The system should support a repeatable positioning accuracy of 5m at a maximum range of about 2Km and 1m at close ranges (500m and less).

DESCRIPTION: Optics, RF and GPS cannot be used for navigation underwater due to the short range of electromagnetic signals in water. Since RF/optics cannot be used underwater, inertial navigation systems (INS) and Doppler velocity logs (DVL) are presently used to dead reckon the vessels position. However, since the vessels are slow and the missions are long (several days) drift of the INS resulting in position errors is a problem and the position must be periodically reset using external fixes. Use of underwater transponders is the only GPS independent and reliable approach for achieving this objective at this time.

Simple transponders provide only range information so, at a minimum, two transponders are required to provide a position fix; even with two transponders, the number required to provide positioning service to a large number of vessels

working in a shallow water area is prohibitive due to their relatively short range. Transponders that can provide range and bearing to their hosts can greatly reduce the total number of transponders needed. However, the notional system must be significantly less costly than present commercially available ultra short base line systems (UBSL). Furthermore, the transponder system must be packagable into the 7.5" Semi-Autonomous Hydrographic Reconnaissance Vehicle (SAHRV) [1-2]. Expandable/collapsible mechanisms may be used but the system must be autonomously redeployable to new underwater sites without operator assistance. Power consumption is a consideration so the system must have power conservation features (power switching based on host range, sleep mode, etc.).

In order to achieve the positioning accuracies at the ranges stated, angular accuracy of 1 degree or less is required. At present, ultra-short baseline systems that can achieve this angular accuracy and range are typically $100K or more, and are too large to deploy on the SAHRV vessel. In order to achieve the stated range low frequency acoustics must be used and typically result in prohibitively large transducers. The technical challenge is to develop innovative approaches to this problem that will provide both the required range and bearing accuracy, but in a small deployable package. An additional technical challenge is the development of the required communication protocols between the UUV and the transponder. Commercially available transponders simply send out an acoustic pulse when interrogated by an acoustic pulse of a specific frequency. For the proposed system, communications with the UUV will be required in order to provide the UUV with information such as the location of the transponder (since the system will be relocatable) and the bearing of the UUV from it.

PHASE I: Determine the cost/performance tradeoffs for different design approaches (rotating strobe, directional acoustic array, etc.) to construct a transponder that can provide range and bearing to divers or underwater vessels. Theoretically determine ranges and accuracies given nominal environmental conditions.

PHASE II: Develop a detailed design for the alternative deemed to be superior. Fabricate and test-tank a prototype system. Perform at-sea testing of the prototype system to determine repeatable ranges and accuracies.

PHASE III: Demonstrate producibility and develop an implementation plan for production. Demonstrate the prototype system in one of the ONR Autonomous Operations FNC planned demonstration.

COMMERCIAL POTENTIAL:. The use of UUVs for commercial surveying has commenced (Hugin UUV). At present, accurate positioning of these vessels typically requires the use of a host vessel that is within acoustic range of the UUV (the host being equipped with an short baseline positioning system), or the deployment and successive redeployments of several range-only transponders to cover the entire survey area. Bearing capable transponders will provide a method for greatly reducing the cost of these operations.

REFERENCES:
1. The Navy Unmanned Undersea Vehicle (UUV) Master Plan, 20APR00
2. BAA 01-12 Proposer information package http://www.onr.navy.mil/02/baa/baa01-012/pip/pip.htm

KEYWORDS: Underwater Positioning, Acoustic Transponders

N02-083 TITLE: <u>Demonstration of a Rugged, Compact, Narrow Bandpass Optical Filter Suitable for Imaging Applications</u>

TECHNOLOGY AREAS: Sensors, Electronics

OBJECTIVE: Develop and demonstrate a rugged, narrow bandpass optical filter with the following properties. The filter to maintain its optical performance under relatively severe mechanical conditions typical for a space or military application. The filter bandpass must be relatively narrow to permit observation/isolation of fine spectral filter typical of LIDAR applications and other imaging/remote sensing applications. The filter must be relatively light weight and compact to be accommodated within a broad range of existing instruments. The filter must be tunable to allow spectroscopic chopping between spectral features within the band as well as detailed studies of spectroscopic profiles.

Finally, the filter must have a reasonable aperture and acceptance angles for incoming radiation. All these properties allow the final objective of a spectroscopically pure images of a scene to be reached.

DESCRIPTION: Narrow bandpass, tunable optical filters are presently utilized in a wide variety of applications. The present interferometric based designs are generally relatively fragile and/or large. Examples include mechanically controlled Michelson and Fabry-Perot interferometers and Lyot or Solc optical filters. However, modern optomechanical design and numerical control fabrication practices make possible some relatively unique solutions to this classical problem. Novel approaches include monolithic assemblies, optical contacting and use of modern nanosensors and actuators, in particular capacitance micrometers and piezoelectric crystals. However, these techniques have yet to be successfully demonstrated in a prototype unit. The goal of this research program is to successfully demonstrate such a filter technology for future programs. The perceived requirements are as follows. The wavelength range is for visible wavelengths. However, possible later extensions of this technology into the infrared and ultraviolet are highly desirable. The filter technology should be capable of surviving a relatively severe mechanical environment. Typical environments are characterized by 20grms random vibration of 1 minute duration and 50g low frequency shock (6msec duration). The thermal operational range should be from 5 to 35 degrees C with survival from –10 to +50 degrees C. The filter bandpass may be determined at manufacture. Possible bandpasses should span the range from 0.01-0.07nm of full width at half maximum. The filter peak wavelength should be stable to with 0.05 of the filter full width at half maximum over a 0.5 degree C excursion. The filter rejection should be sufficient to allow relatively pure images of a particular scene to be obtained. The filter tunable range should be at least 0.6nm around a central wavelength. The filter must be able to change wavelengths within this range in a few seconds. The filter must have an aperture of >39mm in diameter and a reasonably large acceptance angle for incoming radiation. The proposed design must be compact and light.

PHASE I: Develop a design of a tunable filter system. Prepare preliminary error budgets and mechanical stress analysis of the filter system. Measure relevant optical performance of components as needed to establish feasibility of the filter system.

PHASE II: Demonstration of filter technology. Successfully design, fabricate, assemble and test a prototype filter. Testing to include environmental testing and optical characterization.

PHASE III: Develop filters for terrestrial and space based LIDAR applications, develop narrow bandpass filters for space weather sensing instruments, develop filters for airborne and naval remote sensing applications.

COMMERCIAL POTENTIAL: Optical networks, atmospheric LIDAR stations, remote sensing satellites and terrestrial stations would potentially benefit from this type of filter technology.

REFERENCES:

1. Fabry-Perot Interferometers, G. Hernandez, Cambridge University Press, 1986.
2. Principles of Optics, Max Born and Emil Wolfe, Pergamon Press, 1964.

KEYWORDS: Optical Filter, Fabry Perot, Interferometer, Narrow Bandpass

N02-084 TITLE: Calibrated CMOS Active Pixel Sensor

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop and demonstrate a CMOS active pixel sensor (APS) that has high sensitivity and stable calibration in the extreme ultraviolet (EUV) and x-ray wavelength regions and that is robust against radiation damage.

DESCRIPTION: Calibrated single-pixel silicon photodiode sensors have been utilized to measure the absolute EUV and x-ray radiation from the Sun. These measurements serve as input to computer models that simulate and forecast space weather and adverse effects on satellite orbits and performance and on military and civilian long-range communications and surveillance. The complementary metal-oxide silicon (CMOS) technology has evolved to the stage that it is now

feasible to fabricate multi-pixel arrays of diodes that can be absolutely calibrated and are robust against radiation damage. The CMOS technology has advantages over the more traditional charge-coupled device (CCD) technology. In contrast to CCD sensors, the individual pixels of a CMOS sensor can be addressed and read out without transferring electrical charge along columns of pixels. Thus CMOS sensors are less susceptible to radiation damage of the type that would disable entire regions of a CCD sensor. In the case that only the data from a particular area of the sensor is of interest, only that area of the CMOS sensor can be read out at a considerable time savings compared to a CCD sensor. In addition, signal processing can be efficiently performed at the chip level of a CMOS sensor. CMOS sensors typically consume less power, are more efficient, and are less costly to fabricate than CCD sensors, and these are advantages for flight instrumentation.

PHASE I: Develop a detailed design of a CMOS APS with a pixel format larger than 256x256, pixel size less than 100 microns, high sensitivity (0.2 A/W or greater) in the EUV and x-ray regions with radiation hardness, and that can be absolutely calibrated to 5% accuracy or better in the EUV and x-ray regions.

PHASE II: Fabricate the CMOS APS and evaluate its performance with regard to sensitivity, speed, dark current, radiation damage, and stability of calibration.

PHASE III: Demonstrate producibility and develop an implementation plan for new production and utilization in space instrumentation.

COMMERCIAL POTENTIAL: CMOS sensor technology has evolving to the stage that it is beginning to be competitive with CCD technology for commercial imaging systems. In radiation environments, such as space and medical situations, CMOS sensors are in some cases superior to CCD sensors. An absolutely calibrated CMOS sensor would find applications in medical and scientific applications.

REFERENCES:

1. "Radiation Effects in a CMOS Active Pixel Sensor," G. R. Hopkins, IEEE Trans. Nuclear Science 47, 2480 (2000).
2. "Development and Characterization of Active Pixel Sensors for Space Applications," O. Saint-Pe et al., SPIE Conference on Photonics for Space Environments VI, vol. 3440, 24 (1998).

KEYWORDS: Active Pixel Sensor, CMOS

N02-085 TITLE: A Compact Fluorescence-Scattering System

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop and demonstrate a compact and low-maintenance system capable of characterizing dissolved and particulate components of coastal waters by their elastic and inelastic scattering, and spectral attenuation properties. The system is expected to operate in a variety of platforms including moorings, automated underwater vehicles (AUV) and oceanographic multi-sensor racks. The users of the systems are expected to be non-optics specialized operational Navy and industry personnel.

DESCRIPTION: A compact and low-maintenance instrument capable of performing simultaneous measurements of water spectral attenuation and scattering (elastic and inelastic) at different spectral bands and scattering angles is required. The system must be capable of providing measurements at least at three incident wavelengths (350 nm, 532 nm and 660 nm), and to measure scattering properties at angles of 30, 90, and 180 degrees with respect to the beam propagation. Such measurements will enable the configuration of the scattering properties of the water column and the assessment of turbidity or nephelometric type of data, routinely used to obtain water clarity estimates. The system will need to include self-calibrations and internal standards for elastic and inelastic measurements, and to correct for energy excitation calibration and sub-calibrations for pigments and color dissolved organic matter (CDOM). It should be designed in a robust configuration to withstand deployment to depths up to 500m in the ocean. It should be compact enough to be installed on AUV, deployed in an oceanographic instrument rack or placed in a mooring. The device should also provide a data acquisition system that allows for easy download of data and simple graphics. It is expected

that the data will be continuously recorded and be depth and temperature compensated, if necessary. Data transmission should be instantaneous to surface in order to keep real time data logging. The system should provide the option of real-time operation via a conductive wire or be battery-operated to record data.

PHASE I: Demonstrate (1) proof of concept, and (2) the feasibility of developing a Laser Diode-based system capable of measuring forward-backward scattering at the angles stipulated, attenuation and fluorescence of at least three different wavelengths (350nm, 532nm, 660nm), which are relevant for dissolved and particulate water components. This phase should produce the basic design of the laser-diode system and a proof of concept. This phase should also include a "bread board" type of instrument capable of demonstrating the feasibility of the conceptual design and measurements proposed.

PHASE II: Develop a working prototype instrument and its data acquisition software package. Data should be logged and displayed in real-time. The software package should be simple to operate and designed to be user friendly. This phase should provide a prototype instrument capable of being deployed in the field and of providing the optical parameters required.

PHASE III: Develop useful version of the instrument.

COMMERCIAL POTENTIAL: This proposal expects to provide a highly sensitive, accurate, efficient, extremely rugged, cost effective and user-friendly sensing system for a variety of applications, including determination of the "in water" dissolved and particulate components important in the determination of water purity, industrial water monitoring, water drinking plants, water reservoirs, chemical plant effluents and other environmental applications. Among the users of these systems are non-specialized personnel in municipalities, chemical and thermal plants, and water bottling plants.

REFERENCES:

1. Desiderio, R.A., C. Moore, C. Lantz, and T.J. Cowles, (1997). Multiple excitation fluorometer for in situ oceanographic applications, Applied Optics 36(6): 1289–1296.
2. Iturriaga, R., S. Bower (1993): Micro photometric analysis of the spectral absorption and fluorescence of individual phytoplankton cells and detrital matter. Pp 377-385. In: Current Methods in Aquatic Microbial Ecology, (P.K. Kemp, B.F. Sherr, E.B.Sherr and J.J Cole, Editors), Lewis Publishers
3. Maffione, R.A., and R.C. Honey (1992). Instrument for measuring the volume scattering function in the backward direction, Ocean Optics XI, Proc. SPIE 1750, 15-26.

KEYWORDS: Fluorescence; Elastic Scattering; Inelastic Scattering; Coastal Water Optical Characterization; In-Water Components; Optical Systems for AUVs and Moorings

N02-086 TITLE: Compact Electronics and Segmented Nuclear Detectors for Radiation Imaging

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Nuclear Technology

OBJECTIVE: Develop three-dimensional position readout of large-volume, highly segmented nuclear strip detectors with fine spatial and high-energy resolution. We limit the scope of the program to include only those detectors appropriate for an advanced Compton camera, or other large-volume gamma camera. The minimum specifications are <2.5 keV FWHM performance, <1 mm position resolution, and a detector >6 cm diameter and >6 mm thick. A key element of the program is to develop an integrated circuit and supporting electronics to provide energy and three-dimensional position readout of highly segmented nuclear radiation detector. The system should be compact and modular, permitting the construction of large detector arrays. Germanium, thick silicon, or low-Z detectors are appropriate. Electronics must provide three-dimensional position resolution either through fast timing of charge development, measurements of fast induced signals on a combination of electrodes, or by some other means. The electronics shall be integrated with sensitive, fully imaging nuclear detectors, with capability of detecting and identifying small amounts of nuclear materials at a distance. System performance requires that the electronics minimize power consumption and physical mass per channel.

DESCRIPTION: Detection of radioactivity in a terrorist or battlefield environment requires detection, identification, and determination of location. Typically detector systems cannot be brought near the subject material and the location is unknown. A new class of gamma ray detectors is being developed for this application. The detector shall provide identification of nuclear materials of strategic interest, determine the location and distribution of these materials, and do so at distances and with exposure times superior to conventional instrumentation. Broader applications for the same technology include nuclear medicine and high-energy astrophysics. The detector system is composed of a few thousand highly segmented semiconducting detectors such as germanium, or silicon. An essential component of these detectors are the readout electronics. It is expected that a custom chip for our application in which all of these capabilities are combined into a single chip may be required. There is currently no commercial alternative to this chip. It is important to minimize the power since the chip may need to be cooled along with the detectors, and to minimize mass since passive materials near the detector may interfere with performance.

PHASE I: Develop position readout approach. Develop detector and electronics specifications and architecture to achieve performance. Perform simulations to demonstrate noise and timing performance and estimate power consumption.

PHASE II: Design and fabricate detector and associated electronics. A germanium strip detector is available from commercial sources, which could be appropriate for this project. Demonstrate the performance and specifications outlined in the objectives.

PHASE III: Demonstrate producibility of electronics on large scale in support of production of fieldable nuclear detector systems. Demonstrate the ability to support chip design changes to meet the needs of a broad or evolving market in imaging nuclear detectors.

COMMERCIAL POTENTIAL: The commercial applications of these electronics include PET scanners and other nuclear medicine imaging using new technology being developed for nuclear detection.

REFERENCES:

1. Momayezi et al., "Position resolution in a Ge-strip detector," SPIE Vol. 3768, (1999), p 530.
2. Kroeger et al., "Charge Sensitive Preamplifier and Pulse Shaper using CMOS process for Germanium Spectroscopy," IEEE Trans on Nucl Sci, Vol 42, No 4 (1995), p921.
3. Ericson et al., "A Low-Power, CMOS Peak Detect and Hold Circuit for Nuclear Pulse Spectroscopy", IEEE Trans on Nucl Sci, Vol 42., No 4 (1995), p 724.

KEYWORDS: CMOS, Nuclear Detectors, Nuclear Electronics, Three-Dimensional Readout, Pulse Electronics, Spectroscopy

N02-087 TITLE: Antenna for Shipboard Missile Detection System

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: To develop a high-gain omni-directional shipboard missile defense system antenna for improved intercept capability of inbound Ka-Band missile seekers.

DESCRIPTION: Upcoming anti-ship missile systems are projected to operate in the Ka-Band spectrum. Currently, shipboard systems in this range include directional antennas, limiting the probability-of-detection. The capability to protect against incoming missiles is seriously jeopardized. The proposed omni-directional antenna will be designed to replace the existing element. The element must be omni-directional with a minimum gain of 15 dBi and a vertical beam peak at the horizon. The polarization can be horizontal, vertical or both. Physically, the element could be housed in a cylindrical radome approximately 12 inches high and 3 inches in diameter.

PHASE I – Establish the technical requirements and design parameters, including effective gain, elevation beamwith,

and elevation boresite. Design an engineering model for extensive RF testing and evaluation.

PHASE II – Develop and provide a prototype design optimized for shipboard operation, including mechanical mounting. Naval Research Laboratory will provide engineering support in defining compatible mounting techniques.

PHASE III – Provide qualification testing to assure shipboard reliability. The contractor will produce the qualification antenna, conduct the environmental testing, and will also be responsible for generating a final test report.

COMMERCIAL POTENTIAL: Shipboard surveillance and collision avoidance systems.

REFERENCES:
1. Antenna Engineering Handbook, Henry Jasik, McGraw-Hill Book Company, Inc., N.Y., 1961, pp. 9-11 to 9-14.
2. Antenna Analysis, Edward A. Wolff, John Wiley & Sons, Inc., N.Y., 1966, pp. 179 – 189, pp. 409 – 412.

KEY WORDS: Slot-Array, Omni-Directional, Gain, Missile, Probability-Of-Detection, Shipboard

N02-088 TITLE: Buoyancy Control Package for Miniature Undersea Sensors

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop a miniature buoyancy adjustment package to maintain miniature undersea sensors at desired depth and/or temperature contour.

DESCRIPTION: Littoral antisubmarine warfare (ASW) and surveillance plans incorporate a vision of distributed network of miniature, neutrally buoyant undersea sensors capable of maintaining desired depth at 10 to 1,000 meters or position on a 5 to 20 degree Celsius temperature contour. Currently available actively self-controlled buoyancy packages are approximately 1/2 cubic foot. The goal of this project is the development of a miniature adjustable buoyancy module for a sensor packages 4 oz or smaller. The buoyancy module would preferably not require electrical energy; however, micropower concepts will be considered. A buoyancy package small compared to 4 oz is desired. This effort will require innovative research in micromachining and miniaturization technologies.

PHASE I: Provide proof of concept of actively self-adjustable buoyancy modules for miniature sensors.

PHASE II: Develop and demonstrate a small active, self-adjustable buoyancy module, designed to maintain the sensor at either fixed pressure (depth) or at a fixed temperature strata in the ocean.

PHASE III: If a successful device is demonstrated, Phase III will address manufacture or licensing of the Phase II product.

COMMERCIAL POTENTIAL: The developed buoyancy packages and associated sensors have direct utility for oceanographic sampling and for mapping dynamic undersea phenomena by chemical, oil, and regulatory agencies.

REFERENCES:
1. Simonetti, Paul., and D.C. Webb. (1997) A Simplified Approach to the Prediction and Optimization of Performance of Underwater Gliders. In Press. Proceedings of the 10th International Symposium on Unmanned Untethered Submersible Technology.
2. Stommel, Henry. (1989) The SLOCUM Mission, Oceanography, April 1989, pp. 22-25.

KEYWORDS: Undersea Sensors, Distributed Sampling, Buoyancy Control, Distributed Sensors

N02-089 TITLE: Estimation of the Electromagnetic Energy Protection Provided for Electronic Equipment by Various Dielectric Materials and Shielding Configurations

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

OBJECTIVE: Develop and demonstrate analysis and modeling techniques and strategies that can estimate the shielding effectiveness over a wide range of frequencies of complex electronic enclosures such as buildings, vans, and trailers by extrapolation from shielding effectiveness data taken on various similar facilities.

DESCRIPTION: Electronic systems in the US are susceptible to high power electromagnetic energy. Protection of these systems by conventional EMP hardened structures or by the use of tempest structures is generally too costly. If we knew the susceptibility of the systems installed in buildings or vans more accurately, a lower cost solution for protection would be available.

The challenge is to obtain a quantitative answer as to how vulnerable these electronic systems are to an RF attack when they are in an office or part of a field military installation. Computer systems for example are available in a variety of containers or chassis. They have a number of external connections – mouse, keyboard, monitor, power cord, network connection, etc. They are also in rooms constructed of different materials, with different shapes, and with different types of furniture in the room. The rooms are part of a building, the next level encasement. Around the electronic circuitry in a computer system, there are many barriers and many avenues of entry for high power electromagnetic energy. How does one estimate the RF shielding effectiveness of a shelter (room, building, van) on a computer or other electronic equipment inside the shelter given shielding and vulnerability information from other similar structures and facilities?

Statistical electromagnetics may assist in determining the electromagnetic fields interior to an enclosure. Numerical analysis modeling provides a valuable analysis tool for the interactions of impinging electromagnetic fields on complex electronic systems. Frequency domain (Green's, Finite Element, Method of Moments, Wavelet, Integral Equation, etc) based methods provide rapid prototyping for narrow band incident fields. Time domain (Finite Difference Time Domain, Transmission Line Matrix, etc) based methods provide complex model simulations for pulsed incident fields. Both numerical classes provide valuable insight and modeling advantages into the interactions of the fields on the electronic systems in a wide variety of environmental conditions (atmosphere and surrounding structures).

From these techniques and others, the need remains to develop algorithms and processes that can estimate the susceptibility of the electronic systems interior to an enclosure such as a van, a building, or a trailer, by extrapolation from the shielding and electromagnetic field measurements of other similar structures. The goal then is a set of usable tools to perform these calculations and extrapolations preferably on a man portable computer system.

PHASE I: Investigate the techniques and methods available to estimate the electromagnetic shielding effectiveness of irregular complex structures, e.g buildings. Provide a compendium and perform a comparison of the methods describing under what conditions they are useful and under what conditions they are not applicable

PHASE II: Implement and/or combine the applicable techniques and models. Demonstrate their utility on a specific building structure to verify the accuracy of the estimation process.

PHASE III: Package the analysis capabilities onto a PC for portability for ultimate use at civilian as well as military locations.

COMMERCIAL POTENTIAL: Many commercial facilities are also vulnerable to high-energy electromagnetic fields. The result from this research and development will provide a product to allow the commercial user to quickly and accurately understand the susceptibility of his/her electronic equipment at its specific location. The commercial user will then be able to take the appropriate action to protect the equipment from the RF energy.

KEYWORDS: Electromagnetic Modeling, Electromagnetic Susceptibility, Electromagnetic Protection, Complex Electronic Systems, High-Power Microwave, Electronic Warfare Self-Protection

N02-090 TITLE: Numerical Modeling of Complex Electronic Systems

TECHNOLOGY AREAS: Information Systems, Electronics

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: OPNAV N89 – Operational Naval Group N8 – Special Technology Countermeasures Joint Programs Office

OBJECTIVE: Develop and demonstrate multi-method numerical modeling strategies that simulate near-field electromagnetic interactions with electrically large scattering elements such as buildings housing complex information systems. The modeling strategies must be scalable to increasing levels of detail as computational capabilities improve, be capable of user parameterization for rapid material and geometry entry through input files, and allow access to multiple simulation kernels through the same user interface.

DESCRIPTION: Numerical modeling provides a valuable analysis tool for the interactions of impinging electromagnetic fields on complex electronic systems. A multi-method modeling approach is essential due to the wide range of excitation, continuous wave to near-field time transient, and the complexity of electrically large systems with relatively small detail. Frequency domain (Green's, Finite Element, Method of Moments, Wavelet, Integral Equation, etc) based methods provide efficient simulations for narrow band incident fields. Time domain (Finite Difference Time Domain, Transmission Line Matrix, etc) based methods provide complex model simulations for pulsed incident fields. Both numerical classes provide modeling advantages and valuable insight into the interactions of the fields on the electronic systems, however combining results from multiple separate kernels is cumbersome if not prohibitive due to the user interaction and interpretation required. A multi-method numerical simulation strategy could provide a platform for study of electromagnetic interactions of large systems, providing intuition for the measured results currently available and assist in understanding future measurements. Very flexible data entry with capabilities for program generation of the input files is a requirement. This will allow for numerous automated simulations across a wide variety of conditions, for example investigating hundreds of unique antenna structure systems with thousands of variations for sensitivity analysis. Post processing capabilities should also be flexible to allow semi-automatic collection of the results across a set of simulations.

PHASE I: Design and develop time and frequency domain numerical modeling strategies for analysis of electromagnetic energy coupled to structures housing complex electronic systems. Multiple existing algorithms should be utilized and the problem should be scalable to increasing levels of detail. Utilize proof-of-concept modeled systems to establish numerical modeling constraints. Parameterization of the numerical model is a significant requirement, therefore input must be available through input text files and not solely by graphical means.

PHASE II: Determine the extent of capabilities for a numerical modeling approach that is to be performed. Demonstrate detailed simulation of several operational electronic systems within a complex environment for a variety of incident field waveforms and energy levels. The level of detail should be significantly improved from Phase I.

PHASE III: Demonstrate production capabilities to bring the numerical modeling approach into the mainstream markets of facilities design and through characterization of the electromagnetic environment define or improve the operational robustness of electronic systems in the presence of adverse electric and magnetic fields.

COMMERCIAL POTENTIAL: The commercial producers and the end users of electronic systems (computers, control devices, communications devices) will benefit from enhanced reliability under a wide variety of electromagnetic operational regimes. The increased reliability has multiple benefits from overall system stability to lower maintenance and capital installation costs.

KEYWORDS: Numerical Modeling, Scalable Detail, Rapid Prototyping, Complex Electronic Systems, High-Power Microwave, Electronic Warfare Self-Protection

N02-091 TITLE: <u>Data Standardization and Brokering</u>

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: OPNAV N89 – Operational Naval Group N8 – Special Technology Countermeasures Joint Programs Office

OBJECTIVE: Provide a central medium (broker) to leverage software applications and data by creating a common, platform-independent data schema to accommodate the myriad of databases and data processing methodologies being managed by various communities supporting critical infrastructure assurance initiatives.

DESCRIPTION: Presidential Decision Directive 63 (PDD-63) identified the need for public-private partnerships and information sharing. This effort would create an engine to act as a broker to query databases and data manipulation processes using XML (eXtensible Markup Language) document request information transport medium and using SOAP (Simple Object Access Protocol) to facilitate the exchange of the information. The use of XML would make leveraging the engine platform independent. Thus, the data could be gathered and delivered to any platform with an HTTP connection, where the engine would transform the data into a portable XML format. The software application that requests the information from the broker would then receive the information in a published data structure schema. Overall, this would provide a common resource of standardized data to be communicated between and among the respective players involved in protecting our nation's critical infrastructure, regardless of platform or application, thereby increasing the efficiency and effectiveness of data exchanges, data mining, and analysis efforts.

PHASE I: Design a foundation XML data schema to control brokered data to consumer applications and provide a basis for a scalable data distribution system.

PHASE II: Develop an extensible SOAP brokering application for transforming data-center data into a standardized data structure that returns the transformed data to the consumer application as an XML document.

PHASE III: Develop data server applications for providing the requests from the data broker system. Incorporate data-schema definitions for brokered data into the broker architecture. Develop a data consumer application for prototyping. Since data will be platform independent, developers can engineer applications to leverage any or all of the available data in any language and on any platform.

COMMERCIAL POTENTIAL: This capability could be widely employed to facilitate the sharing of information, regardless of platform or application, across not only DoD entities but all national and commercial activities engaged in infrastructure assurance activities for the benefit of the nation.

REFERENCES:

1. The Clinton Administration's Policy on Critical Infrastructure Protection: Presidential Decision Directive 63, May 22, 1998 (available on the Internet).
2. W3C Architecture Domain, July 2001 [Online] http://www.w3.org/XML/
3. EXtensible Markup Language (XML), created by the World Wide Web Consortium (W3C) is a markup language used as a way to structure, describe, store and send information. It provides a portable means for applications and systems to communicate regardless of platform. Extensible being the keyword, describing data is not limited to a set of tags, such as with HTML; in fact, XML tags used to describe and relate the data can be anything, thus adding versatility to the data and making it easier for the end user to understand and process the data and meta-data. XML has been used in a variety of implementations within software development. A few examples of these implementations include: 1)Web-based application discovery: XML is used to describe application integration components. The core Intranet platform searches for available applications and incorporates them based on data provided in the XML document for each application. 2) Database architecture implementation: XML is used to store database architecture information which is then leveraged to upgrade databases related to installed client-server applications.
4. W3C Architecture Domain, July 2001, [Online] http://www.w3.org/TR/soap12/
5. Simple Object Access Protocol (SOAP) is a lightweight protocol for exchange of information in a decentralized, distributed environment. SOAP is an XML based protocol that consists of three parts: an envelope that defines a framework for describing what is in a message and how to process it, a set of encoding rules for expressing instances of application-defined data-types, and a convention for representing remote procedure calls and responses

via standard Internet HTTP. SOAP has been submitted to the W3C standardization process. Several companies have developed solutions using the SOAP specification including the Apache SOAP Toolkit from IBM, Microsoft .NET, and Microsoft SOAP Toolkit v2.

KEYWORDS: Data Standardization, Data Brokering, Infrastructure Assurance, Infrastructure Protection, Information Sharing, Database Integration

N02-092 TITLE: <u>Infrastructure Vulnerability Analysis System</u>

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: OPNAV N89 – Operational Naval Group N8 – Special Technology Countermeasures Joint Programs Office

OBJECTIVE: Provide an automated capability to analyze site infrastructure systems and assets, determine vulnerabilities for identified threats and hazards, determine appropriate countermeasures, and provide risk-management decision support to infrastructure owners, operators, and users.

DESCRIPTION: The ability to analyze specific infrastructures such as Transportation (road and rail systems); Telecommunications (long-haul telecommunications and computer networks); Energy (electric power, petroleum, and natural gas); and Water (industrial use) will assist infrastructure owners and operators in reducing the vulnerabilities of these systems. The same information will also assist infrastructure users in understanding their dependencies on these systems and the possible impacts of infrastructure disruptions on their supported operations. The capabilities developed would be focused on infrastructures at sites selected as critical to the successful execution of Department of Defense missions. The general methodology and architecture developed should allow easy incorporation of additional infrastructures and should be easily applied at a site to provide meaningful decision support. In addition to the technical challenge of developing the system, the success of the project will depend on the technical challenges of understanding and modeling each specified infrastructure.

PHASE I: Develop an automated site infrastructure vulnerability analysis capability relating infrastructure systems and assets, threats and hazards, vulnerabilities, and countermeasures for selected initial infrastructures. The tool should have the capability to generate automated, tailored reports to assist decision makers.
PHASE II: Expand the capabilities to include additional selected infrastructures. Make any modifications to the basic analysis tool required to support expanded capabilities.
PHASE III: Prepare a user-friendly manual and training tutorial to facilitate distribution and employment of the tool by military and commercial infrastructure providers working to reduce vulnerabilities of networks whose loss or disruption could adversely affect military missions of the national economy.

COMMERCIAL POTENTIAL: This system and its associated databases could be used by commercial infrastructure providers to analyze their network vulnerabilities and identify their best options for risk reduction. With the focus provided by the President's Commission for Critical Infrastructure Protection (PCCIP), there is widespread commercial and government interest in this topic, so the dual use potential of an infrastructure vulnerability analysis system of this nature is self-evident.

KEYWORDS: Decision Support Automation, Infrastructure Assurance, Vulnerability Assessment, Risk Mitigation, Infrastructure Protection, Risk Management

REFERENCES:
1. Executive Order #13010 (July 1996)
2. Presidential Commission on Critical Infrastructure Protection (October 1997)
3. Presidential Decision Directive # 63 (May 1998)
4. DoD Directive 5160.54 (January 1998)
5. http://www.nswc.navy.mil/IAP

N02-093 TITLE: Virtual-node Programming Environment

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop, demonstrate, and apply a virtual-node programming environment and software development approach that permits algorithms and software to be developed on any single-node machine (PC, workstation, or one node of a parallel machine), and, after development, to be transferred with minimal effort to any multi-node, real-time system.

DESCRIPTION: Developing real-time embedded systems, such as those that apply complex scientific algorithms to reduce sensor data, often begins with development of algorithms and software on a high performance mainframe computer using single-threaded programming architecture. The R&D algorithm development phase is generally unconstrained by real-time throughput requirements. This traditional approach, however, requires a costly total rewrite of the algorithms to real-time parallel processor architecture. Developing an approach that eliminates the need for the rewrite step could reduce cost and shorten development time considerably.

PHASE I: Conduct research on standards and coding methodologies for enhancing the portability of real-time parallel code to COTS processors. Many standards exist or are emerging within various academic communities, commercial groups, and government groups that address the need for code portability. These include standards for managing interprocessor communication in a distributed processor environment (e.g., CORBA, MPI), standardized science library calls (e.g., VSIPL), standard OS calls (POSIX calls), and shared memory allocation methods. Develop these standards into programming guidelines for real-time parallel code development

PHASE II: Develop and test a virtual-node programming environment using the portable-code standards developed in Phase I. The coding framework shall provide a structure that allows multiple virtual processors to be resident on a single node. All inter-node communication and shared memory shall be emulated. Threads emulating the host processor and all slaves with user-defined "physical" connections shall calculate and communicate among themselves to faithfully mimic the target topology. A multi-thread debugger shall be developed, along the lines of a multi-node debugger on the target system, to allow each virtual processor to be debugged and profiled. Demonstrate the utility of the Phase I standards by Re-hosting code developed on a single node machine to a true multi-node system.

PHASE III: Use the approach and virtual-node programming environment developed in Phases I and II to convert existing machine-dependent code, which performs complex data-reduction algorithms, to machine-independent code that can be easily re-hosted, to take advantage of advances in computing technology advances, and easily modified, as improved algorithms are developed.

COMMERCIAL POTENTIAL: This software-development approach and programming environment could be applied in any work environment where complex algorithms are used on multi-node computers to reduce large amounts of data.

KEYWORDS: Programming, Development, Environment, Parallel, Portability, Embedded

N02-094 TITLE: Detection and Tracking of Low RCS Watercraft

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Battlespace

OBJECTIVE: Develop techniques and algorithms to detect, track and classify low radar cross-section small and/or low-RCS watercraft in the littoral zone using real aperture and/or synthetic aperture radar.

DESCRIPTION: The Navy is increasingly concerned with battlespace awareness in littoral operations. It is desirable to have the ability to detect and track not only large ocean going vessels with large radar cross-sections, but smaller, more covert craft as well. These craft can have radar cross-sections as low as 0.1m^2 and be capable of high speeds. Innovative concepts and algorithms are sought to detect, track and classify these ships in the littoral region using advanced radar technology, signal processing, and knowledge of the physical processes in the littoral ocean

environment. Possible approaches include: Multiple hypothesis, Bayesian field track-before-detect algorithms coupled with ISAR and template matching techniques for target classification.

PHASE I: Based on known signature and littoral ocean clutter characteristics, develop algorithm (radar deployment and data processing approach) to detect and track low cross section vessels.

PHASE II: Implement and test Phase I detection and tracking algorithms for low radar cross section waterborne vessels in the littoral region.

PHASE III: Transfer the algorithms developed in Phase II to an existing Navy Acquisition Program.

COMMERCIAL POTENTIAL: U.S. Coast Guard (and foreign counterparts) could apply the techniques developed here to improve effectiveness in search-and-rescue operations, fishery monitoring, and counter-drug efforts.

KEYWORDS: Radar, Tracking, Oceanography, RCS, Littoral, Classification

N02-095 TITLE: Detection and Classification of Drifting Mines

TECHNOLOGY AREAS: Information Systems, Sensors, Battlespace

OBJECTIVE: Develop techniques and algorithms to detect, track, and classify (discriminate) floating mine–like objects using real aperture radar.

DESCRIPTION: Floating mines present a potential threat to any Naval force in their vicinity. The ability to detect and classify these objects is of paramount importance to the Navy. Also important, is the ability to have a wide search area over which the probability of detecting floating mines is high. Remote sensing provides a means wherein both of these objectives can be met. This topic seeks innovative concepts for existing radar systems to accomplish these goals.

PHASE I: Investigate the phenomenology of drifting mine-like objects as well as potential sources of false alarms. Investigate what capabilities may already exist in this area and how they can be generalized to other radar systems.

PHASE II: Develop advanced processing capabilities exploiting the phenomenology from Phase I to detect, track, and classify drifting mine-like objects.

PHASE III: Transfer this capability to existing Navy radar system Acquisition Program.

COMMERCIAL POTENTIAL: The techniques developed may have utility in drug-enforcement and other law enforcement scenarios.

KEYWORDS: Mines, Floating, Detection, Classification, Radar, Oceanography

N02-096 TITLE: Very Low Noise, High Efficiency Propeller Designs for Small UAVs

TECHNOLOGY AREAS: Air Platform, Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IV: PMR 51 – Navy Low/Counterlow Observables Policy, Technology and Projects Office

OBJECTIVE: Develop approaches and designs to reduce the noise associated with propellers for small UAVs to levels consistent with the other components of the propulsion package.

DESCRIPTION: Propellers are fast becoming the dominant noise source in small UAVs. The sources of noise in these

small (7"-15") propellers have not been well studied. Most propellers in this size range are designed for and marketed to model aircraft hobbyists who are generally not overly concerned with propeller noise issues since their engine noise is significantly greater. The Navy is developing small UAVs, using either electric or liquid fuel engines, which are significantly quieter than those used by hobbyists. Therefore, propeller noise is becoming a significant issue for these small UAVs. Additionally, the propulsive efficiency of these propellers is important also.

This topic addresses the design and development of novel propeller shapes and configurations that significantly reduce the radiated noise of these small propellers while simultaneously maintaining relatively high propulsive efficiency. Furthermore, since the intended use for the propellers is small, very low cost, expendable UAVs, the final manufactured cost of these low noise propellers must be inexpensive.

PHASE I: Design, fabricate, test, and evaluate low noise propellers (with approximately a 9" dia. X 6" pitch) that can provide a 12 dB average reduction in radiated noise (20 Hz to 20 kHz at 6,000 to 12,500 rpm) compared to the best equivalent commercially available propellers being sold in the hobby industry today. Modify designs to provide at least 75% propulsive efficiency over the 8,000 to 10,000 rpm range. Select appropriate materials for propeller construction so that it would be expected to remain dimensionally stable to design tolerances after 24 hour exposure to temperatures of 140F and humidity of >60%. Provide an analysis with supporting documentation that explains how final production design will meet or exceed low cost, weight, acoustic, and propulsive efficiency objectives. Provide five propellers for Navy test and evaluation.

PHASE II: Continue development of low noise propellers for small UAVs. Reduce the radiated noise level of the propeller by an additional 8 dB (average, 20 to 20 kHz at 6,000 to 12,500 rpm) over the Phase I goals. Maintain propulsive efficiency of at least 75% over the 7,000 to 11,000 rpm range. Statistically test propeller construction to ensure that the selected propeller design remains dimensionally stable to design tolerances after 24 hour exposure to temperatures of 140F and humidity of >60%. Measure acoustic performance before and after thermal aging and compare results. Provide an analysis with supporting documentation that explains how final production design will meet or exceed low cost, weight, acoustic, and propulsive efficiency objectives in production. Provide twenty-five propellers for Navy test and evaluation.

PHASE III: Demonstrate production capability with the construction and delivery of 250 propellers. Provide statistical data assessing the acoustic and efficiency performance of at least 25 randomly selected samples. Estimate final cost of production.

COMMERCIAL POTENTIAL: Improved low noise engine components would be welcomed by the model aircraft hobby market since noise has been a major source of problems with residents adjoining practice flying fields.

KEYWORDS: Propeller, Noise Reduction

N02-097 TITLE: <u>Cooperative Behavior and Control in Groups of Unmanned Air Vehicles (UAVs)</u>

TECHNOLOGY AREAS: Air Platform, Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IV: PMR 51– Navy Low/Counterlow Observables Policy, Technology and Projects Office

OBJECTIVE: Develop control system approaches suitable for the intra-group command and control in expendable UAVs. Assess the extent of reliable communication required to ensure robust tactical performance. Identify limitations and advantages in particular control architectures.

DESCRIPTION: Small, low cost expendable UAVs are becoming more common. Their perceived value is not only their ability to accomplish the traditional functions of UAVs but also their ability to operate cooperatively in tactical situations where high attrition is expected. This cooperative behavior would allow groups of UAVs to identify their losses internally, reconfigure the force to accommodate these losses, select the most appropriate new "leader(s)",

recombine with remnants of other groups when losses became too extensive, etc. Researchers have suggested several potential control architectures to implement these functions. These span the spectrum from very tightly controlled hierarchical designs through the almost flat designs suggested by the proponents of Artificial Intelligence (AI). The advantages and limitations of this spectrum of architectures needs to be examined for both their utility and their demand on communications bandwidth and reliability to accomplish their tactical goals.

This topic examines the computer simulation and real-world assessment of a variety of robust control structures for a group of expendable UAVs that would have a number of tactical functions in a battlespace. These functions would include (but not be limited to) reconnaissance, search, tracking, relay communications, target identification, and navigational guidance. The group would consist of varying amounts of redundant capability and subjected to a range of subsystem degradation (especially communications) in individual vehicles and total vehicle attrition rates. The simulations would track the average and peak communication rates (inter-vehicle), degradation in the tactical functionality of the total group in face of attrition, and the span, extent, and reliability of the information provided back to the command center. Hybrid or novel architectures are encouraged, particularly to overcome observed weaknesses and limitations identified in previous simulations.

A further aspect to this effort is the development of gradient control, i.e. from man-in-the-loop to supervisory to full autonomous control. This aspect is essential to allow a system to be tested and evaluated as it moves through the process of modeling into real vehicles.

PHASE I: Define potential architectures that can address the control of an expendable UAVs having a variety of capabilities. Perform a preliminary assessment of the architecture using a computer simulation of a UAV force of 10 vehicles selected from a group of vehicles possessing the functions of reconnaissance, search, tracking, relay communications, target identification, and navigational guidance. Determine the minimum level and frequency rate of communication necessary to maintain stable tactical group behavior. Document the results in a report identify portions of the architecture and algorithms exhibiting robust behavior and those portions requiring additional research.

PHASE II: Conduct a more detailed and realistic computer simulation than in Phase I, using a UAV force of 100 vehicles with the functions of reconnaissance, search, tracking, relay communications, target identification, and navigational guidance (as well as other functions to be provided). This simulation will include actual, observed vehicle characteristics measured in the field, and will use the results from sensor and communications system evaluations to enhance simulation accuracy. Determine the extent of redundancy required to accomplish a mission while the group is subjected to degradation of both its inter-vehicle and command communications and also experiences a variety of total vehicle attrition rates. Determine the minimum level and frequency rate of communication necessary to maintain stable tactical group behavior. Determine the capability to reconstitute tactical group behavior after the reestablishment of communications following communication pauses from seconds to hours. Document in detail the best (most robust) architecture in a final report.

PHASE III: Design, test, evaluate and integrate the most robust architecture into a hardware test control system suitable for use on a small, expendable UAV. Use a group of 30 actual UAVs for a battlefield simulation. Correlate battlefield and computer simulations and modify architectures and algorithms. Provide complete control system for field use.

COMMERCIAL POTENTIAL: Real time, robust control architectures are in demand for a variety of manufacturing and service operations. As these systems become more complicated, a more generic approach to them has become essential.

KEYWORDS: Control, Command, Navigation, Cooperative Behavior

N02-098 TITLE: Very Low Noise, High Efficiency Propeller Designs for Small UAVs

TECHNOLOGY AREAS: Air Platform, Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IV: PMR 51– Navy Low/Counterlow Observables Policy, Technology and Projects Office

OBJECTIVE: Develop approaches and designs to reduce the noise associated with engine exhaust in small UAVs to levels consistent with the other components of the propulsion package.

DESCRIPTION: Engine exhaust noise is the dominant noise source in small UAVs. Mufflers for these engines are rather simple and they either are supplied by the engine manufacturer or, in some cases, are designed as aftermarket add-ons. The Navy is currently developing a small UAV that uses a heavy fuel (JP-5) compression ignition engine that is inherently quieter than similar output engines using gasoline. To reduce the noise even further, we need very lightweight, well designed mufflers which reduce the exhaust noise while not adversely affecting efficiency, and perhaps even improving efficiency.

This topic addresses the design and development of novel muffler configurations that significantly reduce the exhaust noise of small (0.25 cid) JP-5 fueled diesel (compression ignition) engines while simultaneously enhancing combustion efficiency in typical operating rpm ranges. Since the exhaust stream of the compression ignition engine is much cooler than that from either glow fuel or gasoline engines, provision must be made to prevent accumulation of water (from the condensation of water vapor from combustion) and both unburned fuel and lubricant. Low weight, non-metallic designs would be preferred. Furthermore, since the intended use for the muffler is a small, very low cost, expendable UAVs, the final production low noise muffler must be inexpensive to manufacture.

PHASE I: Design, fabricate, test, and evaluate a low noise muffler that can provide a 16 dB average reduction in exhaust noise (20 Hz to 20 kHz for an OS-Max FX 0.25 cid engine [modified for diesel] operating at 7,500 to 11,500 rpm using a simulated load) compared to the stock muffler provided by the manufacturer. Evaluate performance for twelve hours uninterrupted operation. Simultaneously, ensure that the backpressure remains low and that the efficiency (SFC) of the engine remains at least constant, though preferably enhanced (10 % prefered) in the range of 8,000 to 10,000 rpm. Weight goal is to be <100 grams, less being much better. Volume constraints are limited to a maximum of 24 cubic inches. Length requirements are that no dimension exceeds 5 inches. Production cost goal is to be $35/each in lots of 1000. Provide an analysis with supporting documentation that explains how final production design will meet or exceed low cost, weight, acoustic, and efficiency objectives. Provide five mufflers for Navy test and evaluation.

PHASE II: Continue development of low noise mufflers for small UAVs. Reduce the radiated noise level of the muffler by an additional 10 dB (average, 20 to 20 kHz for an OS-Max FX 0.25 cid engine [modified for diesel] operating at 7,500 to 11,500 rpm using a simulated load) over the Phase I goals. Evaluate performance for twelve hours uninterrupted operation. Enhance engine efficiency (SFC) in the range of 8,000 to 10,000 rpm by at least 10% (15% prefered) over the factory-supplied muffler. Provide an analysis with supporting statistical data that explains how final production design will meet or exceed low cost, weight, acoustic, and efficiency objectives in production. Provide twenty-five mufflers for Navy test and evaluation.

PHASE III: Demonstrate production capability with the construction and delivery of 250 mufflers. Provide statistical data assessing the acoustic and efficiency performance of at least 25 randomly selected samples. Estimate final cost of production.

COMMERCIAL POTENTIAL: Improved low noise engine components would be welcomed by the model aircraft hobby market since noise has been a major source of problems with residents adjoining practice flying fields.

KEYWORDS: Muffler, Noise Reduction

N02-099 TITLE: Thermal Management Techniques for Bonded Electronic Components

TECHNOLOGY AREAS: Materials/Processes, Electronics

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: PMR 51– Navy Low/Counterlow Observables Policy, Technology and Projects Office

OBJECTIVE: Develop affordable and novel high temperature resistive and thermally conductive polymeric adhesives for bonding high-power electronic structures

DESCRIPTION: The thermal adhesive materials currently available to bond electronic components to dissimilar structural materials may require several hours of pressure and enclave cycle time to cure, thus making the bonding process time consuming. In addition, dissipation of sufficient heat generated by high-power electronic components via the bonding structure is still a challenging problem that shortens the life and performance of the bonded electronic components. Furthermore, quick setting adhesive alternatives available today that are automatically dispensable are unable to provide the heat dissipation required of 5-6watts/mm2 under operational conditions without premature failure. What is sought in this technical effort is a novel polymeric high use temperature adhesive composition of matter compatible with automated dispensing, and a process for non-autoclave cure. The results of the technical effort should afford a new high temperature adhesive product with excellent thermal conductivity and performance in the following criteria: flexibility under thermal cycle, high temperatures and subassembly processes, no impact in performance of radio frequency (RF) circuitry within the electronic components, dimensional stability upon cure and final component production, thermal conductivity/heat dissipation of 5-6watts/mm2, electrical conductivity at 106 S/cm, and adhesion even under hot/wet environmental, vibration, acoustic/physical shock and a variety of other environmental exposure conditions. Clean debonding and repair/rework of the adhesive bond for hardware component replacement on a subassembly are also of prime interest. A simplification of the manufacturing and maintenance processes as described above will make possible the use of high-power and high density compact electronics in larger numbers and in a smaller package.

PHASE I: In Phase I of the effort, the technical work shall require synthesis of the high use temperature conductive, polymeric adhesive composition of matter. Polymer properties to be evaluated include: polymer purity (including metal contaminants) by elemental analysis and molecular weight determination, full thermal analysis including, but not limited to thermal conductivity, 2-D and 3-D CTE, and rheological behavior. Thermo-mechanical and electrical conductivity performance at both environmental temperatures (-40C to + 50C) and fabrication/operational temperatures (+120C to 200C), impact to RF component operations, and elevated humidity conditions shall also be required using best practices test methods appropriate for adhesive performance evaluation. All performance tests (e.g., pull, shear, etc.) shall be conducted using currently used adhesives and conducted in the subassembly for side-by-side comparison and to obtain figure of merit data for the proposed adhesive systems. More preferred approaches for adhesion tests proposed shall incorporate bonding schemes using dissimilar materials with varying CTEs and employment of imaging, spectroscopic and predictive methods to elucidate bond failure mechanisms. To prove bond repairability of the composition of matter, clean debond and rebond rework processes shall be demonstrated. Products of the subject Phase I effort are data and a proof-of-concept composition of matter and process.

PHASE II: In Phase II of the effort, the technical work shall require scale-up of the Phase I candidate composition of matter to the actual size (25 square millimeters) of the representative electronic component. Basic chemical-physical, and American Society of Test and Material (ASTM) standardized thermal, thermo-mechanical and conductivity evaluations shall be conducted again to assure reproducibility of performance properties in scale. In addition, isothermal aging characteristics up to 200 hours at intended environmental temperatures (-40C to +50C) and at the operational temperature shall be performed to evaluate the long term thermal aging characteristics of the adhesive composition. During this phase of the technical effort, additional environmental performance criteria for vibration, acoustic/physical shock, radiation and chemical-biological exposure shall be explored and evaluated with the candidate polymeric adhesive. Additional refinement of the imaging, spectroscopic, or predictive methods cursorily employed in the Phase I effort shall be applied to the Phase II effort. The final portion of the Phase II effort will involve the proof of improved ease of handling during manufacture and repair processes, and compatibility with automated dispensing, using components supplied by the Project Engineer in order to demonstrate and test the bonding capabilities of the new

adhesive composition. Products of the Phase II effort are data and the final component assemblies provided that incorporate the improved adhesives.

COMMERCIAL POTENTIAL: The commercial electronic industries seek new thermally and electrically conductive, dimensionally stable adhesives for bonding electronic components to component substrates which also are environmentally durable and assembly process robust. Some of the current failures in interconnect technology bond integrity may involve the accelerated aging and resulting failure of the component adhesive bonds with exposure to very high temperatures.

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KEYWORDS: Polymeric Adhesive, Thermal Dissipation, Corrosion Prediction, Thermal Conductivity, Non-Autoclave Cure

N02-100 TITLE: Innovative Reverse Engineering Protection for Software

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: PMR 51– Navy Low/Counterlow Observables Policy, Technology and Projects Office

OBJECTIVE: Develop Usable and Novel Approaches to Protecting Software from Reverse Engineering

DESCRIPTION: With the prolific use of commercial processors and other electronic programmable hardware, software becomes the true differentiator in terms of the capability and performance of a system. Thus the development of unique software algorithms or the use of specific and sensitive software data parameters are some of the features that must be protected in order to maintain a warfighting advantage over ones opponent. In addition, the development of such highly capable and sensitive software is a very expensive endeavor. And as a result, there is a growing interest by many to reverse engineer compiled software in order to save hundreds of millions of dollars and save time in terms of research, development, and fielding. By exploiting the ability to reverse engineer software, an opponent can gain a military or competitive advantage with a new capability that they otherwise would not have. In essence, an opponent can make giant leaps forward, advancing their capabilities by years and in some case by decades and thus negate the efforts made by the original software developer. Thus it behooves the original software developer to apply methods that will greatly impede or negate the ability to reverse engineer their code and to exploit sensitive algorithms and data.

PHASE I: In Phase I of the effort, the technical work shall require development of an approach that uses a combination of methods, techniques and procedures for a software obfuscation system, also referred to as a software protection system. Also, to be developed is a model that predicts the level of protection provided based on the identified commercial programming languages to be used, the identified commercial computer/processor to be used, lines of code, and other relevant features. This obfuscation system would protect the original software application to the point that will make it so cost prohibitive and so time consuming to reverse engineer that the code is virtually irreversible. Obfuscating features to be evaluated include: ease of implementing this capability into an existing software application, impact to the performance of the software application, size and reliability of the original software after obfuscation, ability to reverse

engineer the code, and innovativeness of the obfuscation methods applied. All performance tests shall be conducted using currently used obfuscation methods and the original software application for side-by-side comparisons and to obtain figure of merit data for the proposed obfuscation system. More preferred approaches for obfuscation tests proposed shall incorporate quality tests such as: compile and obfuscation time, defects count, run time impact, ability to debug code, code size, etc. Products of the subject Phase I effort are data, predictive models of level of security and a proof-of-concept application of an innovative obfuscation system. In accordance with reference 1 below, the Government shall own or restrict all data rights associated with anti-tamper techniques developed under this Phase.

PHASE II: In Phase II of the effort, the technical work shall require scale-up of the Phase I candidate obfuscation system to an actual software application, supplied by the Project Engineer, consisting of at least 50,000 source lines of code. This software will undergo the compile and obfuscation process. The same best practices software test standards and metrics from Phase I shall be used in these evaluations to assure reproducibility of performance properties in scale. In addition, the executable code will be given to a third party for their evaluation and for them to attempt to reverse engineer the code. During this phase of the technical effort, additional performance criteria are time to reverse engineer the code, amount of information or data gained from reverse engineering, re-usability of reversed engineered code. The final portion of the Phase II effort will involve the proof of ease of inserting this capability into existing software processes. Products of the Phase II effort are test data and the final obfuscated executable code that was produced using the aforementioned innovative obfuscation system. In accordance with reference 1 below, the Government shall own or restrict all data rights associated with anti-tamper techniques developed under this Phase.

COMMERCIAL POTENTIAL: Commercial software industries seek new intellectual property protection methods that can be applied to protect investments in their software products and to ensure adequate profits and adequate return on investments from the sale of these software products. Some of the current failures in software protection technology may involve the short term protection from reverse engineering and thus shorten or eliminate the time needed by a company to recoup its investments in a product.

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KEYWORDS: Obfuscation, Software Protection, Intellectual Property Protection, Reverse Engineering

N02-101 TITLE: <u>Automated Verb Sense Identification</u>

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop an automated software system that recognizes verb phrases in machine-readable written text and identifies the proper meaning or "sense" of the main verb.

DESCRIPTION: Most of the verbs in the English language have multiple meanings or senses, depending on their context. While humans usually have little trouble discerning which sense was intended by the speaker or author, computers have considerable difficulty. The purpose of this project is to develop algorithms that can correctly choose which sense of a verb is correct given its context. We will use a standard set of verb sense categories, such as found in Princeton's WordNet lexicon. We will limit the scope of this project to those verb senses related to political and military activity, but we will develop a system that can be expanded to other domains.

Humans use multiple cues to determine the correct sense of a verb in context, often augmented by significant background knowledge. Much of this effort will be focused on determining the features of the text that will consistently provide the most effective cues to a computer.

PHASE I: Identify and obtain a currently available parser that will accurately identify verb phrases in text. Investigate the features of sample texts to find those most useful for properly assigning verb sense. Evaluate the scope of the task to determine a feasible domain for Phase II.

PHASE II: Develop and deliver a prototype application that will properly identify the "sense" of the main verbs in a body of sample texts drawn from the real world. The application should produce an XML valid reproduction of the original text which inserts the sense of the main verb as an attribute of the XML tags for each verb phrase.

PHASE III: Incorporate technology into JWAC or other DOD information extraction systems.

COMMERCIAL POTENTIAL: The technology developed here could be incorporated into a wide variety of natural language processing tools for use in information extraction, indexing, automatic summarization, and machine translation applications.

KEYWORDS: Linguistics, Natural Language Processing, Information Extraction

N02-102 TITLE: Enhanced Visualization of Modeling and Simulation Processes

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Enable analysts to visualize the spectrum of processes used to perform analysis using a wide range of models and simulations (M&S).

DESCRIPTION: Analysts use M&S across a wide range of subject areas and at varying levels of detail. These M&S and their operating environments are generally not suitable for taking advantage of the full range of human cognitive capabilities. The ability to conduct analysis can be greatly enhanced by using environments which enable the analyst to "see" the M&S as they are built and iteratively manipulated. Models are constructed and simulations are populated from diverse data streams, including databases, text, images and graphics. Some of this data input is done using automated techniques and some is "fat-fingered." In most environments the M&S cannot be viewed until all steps in the construction process are completed. Sometimes, even at that point, the M&S cannot be "viewed" or are cumbersome to view. Additionally, as the M&S are run for various functional and operational scenarios it would be useful to directly observe them as they respond and transition to new end states. The end results of the various M&S runs also need to be visualized in order to provide the analysts and, ultimately, the decision-makers they support, with insight into the problem space being analyzed. This end product visualization will enable better understanding of the M&S results and aid in the evaluation of competing courses of action.

PHASE I: Develop a conceptual architecture for an operating environment to support the visualization of different types of M&S in their stages of construction and manipulation.

PHASE II: Develop a prototype capability to enable visualization of M&S processes in various operating environments. Provide a demonstration of this prototype capability in order for analytic review and assessment of visualization capability in various operating environments.

PHASE III: Provide packaged visualization products capable of being tailored to numerous M&S environments.

COMMERCIAL POTENTIAL: This capability could be used in any M&S environment requiring the population and/or construction of models and/or simulations and their subsequent usage in analytic processes.

KEYWORDS: Visualization, Model, Simulation, Analysis

N02-103 TITLE: Complex Network Route Analysis System

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Enable decision makers to identify the optimal route between nodes within a complex line-node network containing multiple influences with varying degrees of importance.

DESCRIPTION: Identification of the optimal route between two points within a line-node network (e.g., a road network) has demonstrated a utility. An example is mapping software that is used to reduce costs to shippers. The line-node network representing the transportation infrastructure can consist of multiple quality attributes, each quality having a direct impact on the cumulative desirability of any route analyzed (beyond merely line length), each of these qualities may have varying grades of importance, and each segment within the line-node network may have varying degrees of qualitative impact. This analysis effort would use the concept of fuzzy logic to develop an 'expert system' of a complex environment and more accurately select the best option from many possible routes.

PHASE I: Develop a methodology (and associated computer algorithm) for identifying the optimal route between two points within a large and complex line-node network. Further enhance the methodology to incorporate multiple qualities that directly impact the desirability of a negotiated route. Each of these qualities may have varying degrees of importance to the route planner, and each quality may have varying gradients of effect.

PHASE II: Verify and validate the decision-making capability of the system against scenarios that demonstrate the correctness of the solution.

PHASE III: Prepare documentation and user-friendly software packages compatible with ArcView GIS for use by transportation analysts in civilian and military work environments.

COMMERCIAL POTENTIAL: This system could be applied in any work environment involving negotiation of a route with multiple considerations: civilian police SWAT operations in urban terrain, racing sailboat weather routing, resource application for earthquake preparedness, etc.

REFERENCES:
1. Hull, J. W., P-Set: A Brute-Force Methodology for Identifying the Optimal Route Through a Line-Node Network, Old Dominion University, October 2000.

KEYWORDS: Expert System, Fuzzy Logic, Transportation, Logistics, Routing, MOUT

SPACE & NAVAL WARFARE SYSTEMS COMMAND (SPAWAR)

N02-104 TITLE: Daytime Electronic Stellar Imaging

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMW/PMA-156: GPS NAVWAR Program – GPS Integrations

OBJECTIVE: Develop a high dynamic range electronic imaging system for imaging and resolving individual stars during daytime with sufficient accuracy to enable Automated Celestial Navigation (ACN) systems.

DESCRIPTION: The Navy relies heavily on the Global Positioning System (GPS), which is the best navigation system

for worldwide, day-and-night position determination. However, it is well known that GPS signals from space are subject to jamming that may render the GPS system ineffective for some periods of time. The Navy's Balanced Navigation Plan calls for the development of alternate methods of navigation to mitigate this vulnerability.

The development of an ACN system would provide an alternative to GPS that is invulnerable to jamming and completely independent of man-made constructs such as satellites and transmission stations. In order to be viable as a complement to GPS, such an ACN system must provide accuracies comparable to other modern navigation systems. This requires imaging individual stars with angular resolutions on the order of 3 arcsec or less, exposure times on the order of 100 ms or less, both day and night.

The development of current Charge-Coupled-Device (CCD) arrays has been driven by the commercial market for digital cameras. Such microelectronic devices consist of arrays of sensors on a chip yielding up to a few million pixels. Current devices don't have the required sensitivity or dynamic range to image stars in the presence of strong scattering of visible light in the daytime sky. Alternative systems are made using CMOS silicon devices. This topic calls for the development of new electronic sensor arrays that could be based on current CCD or CMOS technology, or use a completely different approach and technology. The preferred spectral region would probably be the near infrared. The goal is a microelectronics-based array of sensor elements that would be mounted in the focal plane of a camera. An electronic readout would then provide a visual and digital image of the field of view. Ideally, the field of view of such an optical system should be at least 3 degrees.

PHASE I: Conduct an assessment of the field of electronic sensors. Quantify the optical requirements needed to image stars in daylight applying whatever digital signal processing and optical filtering that might be required. The spectral window of operation could be adjusted to match the characteristics of the sensor array over a broad range from the near infrared to longer wavelengths. Determine a reasonable approach to develop such a sensor array with the required sensitivity and dynamic range to image stars by daylight at reasonable data rates for shipboard use.

PHASE II: Develop a prototype electronic imaging array for testing and evaluation. Such a prototype should be fabricated in an array of at least 100x100 pixels and characterized for resolution, sensitivity, and dynamic range. This phase calls for actual fabrication of prototype sensor arrays. The arrays should be evaluated, and their optical performance compared to expectations and to the requirements deduced in Phase I.

PHASE III: Transition this R&D effort into a commercially viable product. In addition to the primary goal of an Automated Celestial Navigator, prototype devices should be configured for use in law enforcement and other surveillance applications.

COMMERCIAL POTENTIAL: The continuing development of electronic imagers should have many applications in the commercial markets. In addition, imagers sensitive in the infrared portion of the spectrum would have numerous applications in crime fighting, drug surveillance and interdiction, and home and business intruder-detection systems.

KEYWORDS: Alternate Navigation, Celestial, Electronics, Cameras, Surveillance, Detection, Infrared, Night-Vision, NAVWAR, GPS.

N02-105 TITLE: Advanced Doppler Processing

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II: PMW-182 Mobile Surveillance Systems

OBJECTIVE: The SURTASS/LFA ORD and MNS specify processing and display requirements for on board detection, classification, localization and tracking of threat targets. These requirements form the basis for the development of TX shipboard processing and display upgrades. The objective of this SBIR Topic is to Develop waveforms and processing techiques to improve the ability of the Surveillance Towed Array Sonar System (SURTASS) to exploit target Doppler (i.e., speed related information). SURTASS, depicted in the below figure, is a critical Navy asset which has the

responsibility for detection of threat submarines. The objective of this topic is to increase the probability of detection by exploiting target Doppler. This will require the development of advanced signal processing algorithms using real data and a physics-based development processed.

DESCRIPTION: Doppler shift is an important means of distinguishing between the echoes of moving targets and those from non-moving clutter. However, slow-moving targets (such as diesel-electric submarines) are often lost in the "ridge" of near-zero Doppler clutter. The Navy needs waveforms and processing techniques that improve the ability of SURTASS to exploit near-zero target Doppler thereby increasing the probability of detection of a target.

PHASE I: Develop waveforms and processing concepts to reduce the target masking caused by the near-zero Doppler ridge. Demonstrate their feasibility by processing recorded sonar data.

PHASE II: Develop a prototype based on the concepts developed in Phase I and demonstrate its performance in an at-sea experiment.

PHASE III: Integrate the waveforms and processing techniques into selected Fleet hardware and demonstrate at sea.

COMMERCIAL POTENTIAL: Improved low-Doppler exploitation could be important for commercial air traffic control radars (detecting aircraft on the runway), or in medical ultrasound.

REFERENCES:

1. "Doppler-sensitive active sonar pulse designs for reverberation processing," by T. Collins and P. Atkins, IEE Proceedings on Radar, Sonar and Navigation, vol. 145, no. 6, December 1998, pp. 346-353.
2. "A Study of a Class of Detection Waveforms Having Nearly Ideal Range-Doppler Ambiguity Properties," by John Costas, Proceedings of the IEEE, vol. 72, no. 8, August 1984, pp. 996-1009.

KEYWORDS: Doppler, Sonar, Active, Waveforms, Processing

N02-106 TITLE: <u>Sensor Multi-statics Planning Tool</u>

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II and IV: PMW 182 Mobile Surveillance Systems

OBJECTIVE: Develop techniques for rapid, robust, nonlinear optimization of placement and usage of off-board acoustic and RF sensors and sources in the battlespace.

DESCRIPTION: In order to provide better surveillance coverage of the littorals, the Navy is considering augmenting on-board sensors with remote, off-board autonomous and semi-autonomous (operator-in-the-loop) sensors and sources in both fixed arrays and on autonomous, mobile platforms. The detection performance of a set of sensors is dependent upon not only their correct placement, but also on their ability to survive. Determining the optimal targets, coverage, deployment and subsequent repositioning of a moving multi-static system is a complex, time-varying, and computationally intensive problem. The Navy needs an automated planning tool to help operators optimally deploy and manage such a surveillance system. Additionally, this sensor planning tool must be able to display limited interoperability with sensor data collection and data interpretation tools or systems.

While some research has been conducted to date in underlying associated technologies that may satisfy portions of this requirement, insufficient work has been accomplished not only in the development of smart, complex adaptive systems or sensors, the adaptive resource management of those systems or passive sensors, but particularly in the tools required for the operator to provide oversight and govern the behavior of those systems or sensors to ensure platform or sensor synchronization and performance. Current state of the art technology and research includes only portions of that which is required for development of the necessary tools. For instance:

a) Computational ocean acoustic modeling to predict detection coverage of a group of sensors given their positions (reference [1])
b) Nonlinear inversion techniques to choose the sensor positions that optimize detection coverage (references [2], [3], [4] and [5])
c) Use of the Dempster-Shafer theory of Mathematical Evidence to provide structure and reason based on partial evidence in order to characterize and classify signals or emissions (reference [6])
d) Development of a fuzzy logic based Electronic Attack resource manager to allocate resources distributed over dissimilar platforms (reference [7])

Additionally, further innovation is needed to dramatically improve upon current algorithm speed and robustness. For example, due to the substantial computational complexity of the problem, similar nonlinear inversions require as much as 30 hours of computation time (reference [8]). In addition, some algorithms may be sensitive to mismatch between the actual and modeled atmospheric or ocean environments. Accordingly, under this topic participants will develop robust, rapidly converging nonlinear inversion algorithm(s) that exhibit reduced sensitivity to environmental mismatch and are capable of optimizing sensor placement in near-real time. Finally, several other valid issues will need to be addressed for this topic: sensor or grid latency and information latency; coordinated or synergistic approaches to tasking especially given a heterogeneous sensor mix; de-conflicting tasking or sensor assignments; prioritization of sensor response to either the actual controller or to/among companion sensors; collection or discovery of information from sensors and determining/selection which information must be forwarded.

Research should proceed according to these three phases:

PHASE I: Design the architecture for a robust multi-static planning tool for a moving constellation of autonomous or semi-autonomous sources, sensors and receivers in a time-varying atmospheric (RF) and oceanic (Acoustic) environment.

PHASE II: Develop DII COE-compliant (minimum Level 5, goal of Level 7) software tools for predicting and optimizing the placement, detection performance, and subsequent reallocation of a constellation of off-board autonomous or semi-autonomous sensors and sources. Demonstrate the tools' performance in a simulated or controlled environment that utilizes multiple sensor types, demonstrates operations in several naval mission areas, and which can interface with data collection and data interpretation systems.

PHASE III: Deliver and conduct At-sea demonstration of a GCCS-M Multi-statics Planning Tool software segment.

COMMERCIAL POTENTIAL: A tool for optimizing the locations and maneuvers of multiple moving platforms and sensors would be of significant commercial interest in such industries as package delivery, security and transportation, as well as in local governmental services such as police, ambulance and fire protection.

REFERENCES:

1. Computational Ocean Acoustics, Finn B. Jensen, William A. Kuperman, Michael B. Porter and Henrik Schmidt, 2000.
2. Mathematical Programming:Structures and Algorithms, Jeremy F. Shapiro, John Wiley & Sons, 1979.
3. The Annealing Algorithm, R.H.J.M. Otten and L.P.P.P. van Ginneken, Kluwer AcademicPublishers, 1989.
4. Genetic Algorithms in Search, Optimization and Machine Learning, David E. Goldberg, Addison-Wesley, 1989.
5. "Path Planning for Moving Sensors in Parameter Estimation of Distributed Systems," D. Uciñski and J. Korbicz, Proceedings of the First Workshop on Robot Motion and Control, 1999, IEEE.
6. "Impementation of Battlespace Agents for Network-centric Electronic Warfare", J. Sciortino, J. Smith, B. Kamgar-Parsi, R. Franciose, SPIE 15th AeroSense Symposium, Conference 4396, 2001.
7. "Optimal Allocation of Distributed Resources Using Fuzzy Logic and a Genetic Algorithm", J. Smith and R. Rhyne, NRL Formal Report NRL/FR/5741-00-9970, Naval Research Laboratory, Washington DC 20375, 2000.
8. "Geoacoustic Inversion Via Local, Global And Hybrid Algorithms," Mark R. Fallat and Stan E. Dosso, Journal of the Acoustical Society of America, vol. 105, no. 6, June 1999, pp. 3219-3230.

KEYWORDS: Multi-Static, Sonar, ASW, RF, Line-Of-Bearing, LOB, Geolocation, Direction Finding, DF, Position Optimization, Remote Sensor Control, Off-Board, Information Warfare, IW, Modeling and Simulation, Autonomous

N02-107 TITLE: Fiber Optic Interconnect Technology

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT II: PMW 183, Advanced Deployment System Program

OBJECTIVE: Develop a small, low power, high-bandwidth optical terminus that serves to transfer data between undersea fiber optic cables and undersea platforms.

DESCRIPTION: Undersea surveillance systems typically use fiber optic cables on the ocean bottom to bring acoustic and magnetic senor data back to a fixed shore site where it is processed and analyzed. The topology of these fiber optic cable systems can be quite varied and the lengths of the cable span can potentially be several thousand kilometers in extent. Currently, the sensor information contained in these cable systems cannot be accessed by undersea platforms (UUV, submarines, etc.) that are in the vicinity of the sensors or the cables. A low power terminus can be integrated with the fiber optic to provide a tap point where the information can be transmitted to undersea platforms. A splitter would provide be placed in the surveillance cable so that data could be directed to the terminus. The terminus need to provide a non-physical connection to the undersea platform because of constraints on platform station keeping. It is envisioned that optical transmissions (i.e., blue-green wavelength) between the platform transceiver and the terminus will be used to authorize access, identify and maintain transmission direction, synchronize data transfer between the terminus and the platform, and terminate the connection upon platform demand. fiber optic cables for surveillance purposes may not have power conductors along the cable so the terminus is required to be battery powered. Low power operation, both in stand-by mode and while actively transmitting data, is important to keep the package size of the terminus small.

PHASE I: The contractor shall develop the architecture and proposed design for an underwater optical terminus that is integrated to a fiber optic, surveillance cable. The architecture and design should encompass command capability for controlling the free-space optical link and beam directivity. The architecture and design should identify the transmission protocols and consideration of guaranteed access of service. Some parameters that should serve as goals are: 1-year lifetime with battery power, power usage of 10 watts or less, standoff/reception range to the undersea platform of greater than 30 meters, data transfer rates of several Mbps or greater, and operating water depth of several hundred meters.

PHASE II: The contractor shall develop a laboratory prototype for the critical components of the optical terminus. The laboratory prototype do not need to be demonstrated as a complete unit. However, critical technologies that demonstrate the synchronization (point and track) between source and receiver, the transmission and reception of data, and the anticipated power budget and packaging size for the prototype need to be present.

PHASE III: The contractor shall develop an optical terminus that can be integrated into an Advanced Deployable System (ADS) Development Verification Test (DVT). The contractor would be responsible for the development and delivery of the optical terminus and the platform transceiver. A participating surface ship would deploy the transceiver and remain tethered to the transceiver. The terminus would be integrated with an ADS cable that is carrying OC-1 optical telemetry. The terminus would receive the OC-1 telemetry and strip out null cells before preparing the lower bit rate data for transmission to the platform transceiver. The contractor and ADS program personnel would jointly work on integrating and deploying the optical terminus. The successful demonstration of the terminus would lead to the incorporation of the unit in ADS's Phase III TECHEVAL and OPEVAL.

COMMERCIAL POTENTIAL: Free-space fiber optic terminus devices would be useful to the fiber optic telecommunications industry. A general capability terminus could be used for maintenance monitoring on undersea cables and for direct, free space, optical links in urban environments.

REFERENCES:
1. "Fiber Optics without Fiber", Willebrand, H.A. and Ghuman, B.S., IEEE Spectrum, August 2001, pp. 41-45
2. "Considerations on the Design of Transceivers for Wireless Optical LANs", Aguiar, R. L., Tavares, A., Cura, J. L., Vaconcelos, E., Alves, L. N., Valadas, R., Santos, D. M., IEE Coloquia, June 1999, pp. 2/1-2/17
3. "Wireless Infrared Communications", Kahn, J. M., and Barry, J. B., Proceedings of the IEEE, Volume 85, No. 2, February 1997, pp. 265-298.

KEYWORDS: Fiber Optic, Terminus, Telemetry, Free-Space Optics, Blue-Green, Underwater

N02-108 TITLE: Real-Time Adaptability to the Dynamic Tactical Network

TECHNOLOGY AREAS: Information Systems, Sensors, Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT I: PMW-159 Advanced Tactical Data Link Systems

OBJECTIVE: Investigate smart software technology to provide real-time adaptability to wireless networks.

DESCRIPTION Increased demand on wireless networking has fueled a demand for rapidly adaptive networking architectures. Current static methods of setting up network architectures will not support evolving operations and rapid buildup of forces in a theater. As the number of tactical platforms increases, the need to be able to dynamically modify wireless networks is necessary to meet evolving changes within a theater of operation. The joint service War Fighter community has identified requirements for dynamically adjusting and reallocating capacity among all platforms. Without a dynamic network management capability, the War Fighter will not be able to fully utilize the capability of intra-battle group assets and will be unable to support Navy Theater Wide and strike warfare operations.

The capability is needed to engage high-value Time-Sensitive Targets (TST)/Time Critical Targets (TCT) at standoff range. To satisfy this needed capability the information that is shared with the appropriate platforms must be consistent, accurate and timely. This evolving Dynamic Tactical Network (DTN) is a good solution for the short and mid term.

However, adversary nations are rapidly acquiring and integrating into operational commands, highly lethal weapon systems at an alarming rate. To be one step ahead of our adversaries the DTN must not only be fully automatic but must "know" the type, degree and category of information and what Electronic Counter Measures (ECM) to defend against. The speed to accomplish the above is significantly faster than the typical human reaction time. Smart software technology will be a good solution for this problem. Designing smart learning systems using neural network or other technology-based adaptive learning algorithms is obtainable. Instead of being given a step-by-step procedure for carrying out the desired transformation, the neural network itself generates its own internal rules governing the association, and refines those rules by comparing its results to the examples. Through trial and error, the network literally "learns" by itself, in real-time to find optimum solutions. For example, the "network System" can "learn" if any changes occur in the operational environment and adapt the Tactical Network accordingly. Applying generic learning algorithms (or other smart software technology) to tactical networks, such as Link 16, will provide the capability needed to support Time Critical Strike requirements.

PHASE I: Investigate and identify adaptive learning algorithms that show the most promise in developing a software solution that will provide the capability to vary the tactical network's operations parameters

PHASE II: Develop, test, and demonstrate under realistic conditions the most promising techniques. Validate through certified laboratory and field testing. Provide a cost estimate for future follow-on development. Where it can be done economically, with non-SBIR funding, comparisons of the SBIR-developed technique with other available developments shall be performed.

PHASE III: Appy the software to Link 16 terminals. Demonstrate the developed capability through operational tests.

COMMERCIAL POTENTIAL: Neural Network and adaptive learning technology can be applied to wireless communications, real-time processing, sensors, speech recognition and image processing. Airlines, Banks, and other commercial industries would benefit from this technology.

REFERENCES:

1. DARPA Neural Network Study, Feb 1988
2. Haykin, S. (1994), Neural Networks: A Comprehensive Foundation, NY
3. MIL-STD-6016

KEYWORDS: Link 16, MIDS, JTIDS, Time Critical Strike, Time Sensitive Targets, Dynamic Networking

N02-109 TITLE: Broadband / Reconfigurable Communication Antenna Designs for X Through Q Frequency Bands

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT III: PMW173-31 Submarine Communications

OBJECTIVE: Develop and demonstrate a communications antenna technology, which can operate across the frequency range of X to Q bands and that, can be projected to be suitable for submarine application. Future submarine antenna systems will be required to operate over multiple frequency bands and due to limited volume will consist of one or more antennas subsystems integrated in a multifunction antenna system. Antenna technology proposals can use any currently available or new technique that will make it able tó provided multi/broad band perorations spanning the X to Q bands. Priority will be on multi/broad band functionality per unit volume/weight of technology allocation, which satisfy submarine environmental issues.

DESCRIPTION: The submarine communications antennas operate in a wide range of frequencies and cover both military and civilian bands. Communication takes place in the forms: submarine – submarine, submarine – land station, submarine – satellite. The submarine antennas require high gain over the whole range of frequencies. This can be achieved by reconfiguring the antenna, so it is optimized for each band of operation. The proposed antenna must fit within a restricted available space. As current technologies, such as active phased arrays, drive a spatially federated multi-band antenna solution, the proposed technologies would enable performance improvements by supporting reuse of the same antenna space for multiple frequency bands. The available space is an important factor to the whole design. In addition, a submarine antenna operates within other constrains such as temperature, shock and vibrations and water pressure.

PHASE I: Develop a communications antenna that can operate across the X to Q bands. Clearly state the method or methods used. Provide a feasibility study. Provide simulation models that predict the antenna behavior.

PHASE II: Fabricate a technology component prototype that will be tested. The prototype must be designed with the mechanical and electrical constrains of a submarine in consideration. The simulation and experimental results must be in agreement and demonstrate concept feasibility both in technical performance and potential suitability for submarine application.

PHASE III: Develop a submarine technology demonstration of the new antenna technology prototype under realistic submarine operating stresses. Develop a technology development proposal for transition of the technology to support the production of the new antenna technology. Technology risk reduction and suitability of technology for consideration for insertion to submarine antenna systems is the desired exit criteria of this phase.

COMMERCIAL POTENTIAL: The development and implementation of methods and techniques to the realization of a broadband / Reconfigurable antenna will have commercial potential as the same or similar methods and techniques could apply to existing antennas or the same antenna itself could be used.

REFERENCES:
1. Kim, C. John and Eugen I Muehldorf. Naval Shipboard Communication Systems. Prentice Hall. 1995.
2. Law, E. Preston. Shipboard Antennas. Second Edition. Artech House. 1986.

KEYWORDS: Antennas, Broadband Antennas, Reconfigurable Antennas, Communications Antennas

N02-110 TITLE: Compact, High-Reliability, and Low-Maintenance Cryogenic-Temperature Cooler

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT III/IV: PMW173-31 Submarine Communications

OBJECTIVE: Develop a compact, high-reliability, low-maintenance cooler suitable for the continuous cooling of electronic High-Temperature Superconductor (HTS) components (1 to 3 watts) to a temperature of 77K within a submarine antenna mast or periscope.

DESCRIPTION: High-Temperature Superconductor technology on-board a U. S. Navy submarine could be used to increase satellite communication system capabilities by implementing very high performance components such as extremely-selective RF filters, very quiet Low Noise Amplifiers (LNAs), and very high-speed RF analog-to-digital conversion. Although some potentially suitable HTS semiconductor hardware is available, a refrigeration device capable of providing reliable 77K cooling – within the constraints of the submarine environment – is not. In this type of RF application, the HTS components are usually mounted as closely to the antenna as possible. In a submarine application, the HTS hardware and the refrigeration unit need to be co-located within an antenna mast or periscope.

Very tight physical constraints are imposed upon a cooler that will be mounted within an antenna mast. It must be installed within an eight-inch (inside diameter) tube, which typically contains top-to-bottom vertical components such as waveguides, power conductors, and mounting rails; therefore, the cooler's components must be small, and they must allow flexibility in placement. Excess heat must be dissipated by conduction, liquid cooling, or a heat pipe device; ambient or forced-air cooling solutions usually cannot be implemented within this environment. This cooler cannot generate any vibration that could be conducted through the antenna mast as acoustic noise. Since it is mounted within the antenna mast, no special operator procedures or maintenance can be performed on this cooler unless the mast is dismantled for repair.

The capacity of this cooler should be 1 to 3 watts, with a maximum of 100 watts power input at 80C. Mean Time Between Failure (MTBF) should be greater than 15,000 hours; no scheduled maintenance should be required; and no prohibited materials may be used.

Consideration must also be given to potential production costs; short cool-down time, and the ability of the unit to survive the extreme underwater explosion shock requirements for submarine platforms.

PHASE I: Define requirements through interface with the Navy submarine fleet and communications engineers; design the architecture; and demonstrate the operation of critical components in laboratory bench test.

PHASE II: Build and test a working prototype of the system proposed in Phase I in a laboratory -- simulating the thermal environmental characteristics of a submarine mast. Characterize the cooling performance and MTBF capability.

PHASE III: Build, test, and install systems onto submarine platforms. Support operational testing.

COMMERCIAL POTENTIAL: The cooler described in this topic would find many applications in military applications (communications, electronic warfare, and surveillance); commercial communications applications (e.g., eliminating in-band interference and increasing the operational area of wireless base stations; and increasing bandwidth usage

efficiency of satellite and terrestrial links by employing extremely steep selectivity in receiver filters); and computer microprocessor speed enhancement.

REFERENCES:
1. R. Ross, Cryocoolers 10, Proceedings of the International Cryocooler Conference, Plenum Press, New York, 2000.

KEYWORDS: High Temperature Superconductors, HTS, Cryogenic, Cooler, Refrigeration, Cryocoolers, 77K, Pulse Tube, Sterling, Submarine, Communications

N02-111 TITLE: Automatic Feature Evaluator (AFE)

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT III: PMW189 – Naval Electronic Combat Surveillance Systems

OBJECTIVE: Cryptologic systems have the requirement to reduce manpower requirements through automation and knowledge management. Actionable intelligence is derived from high-density Radio Frequency environments primarily composed of undesired energy. Intelligence mining requires many time consuming analytical processes that must be automated to free analysts to produce timely Indications and Warnings and Force Protection. This objective of this topic is to automatically evaluate "feature sets" for new classes of interest. This process must be automated using artificial intelligence to produce the desired expert system.

DESCRIPTION: Certain Navy sensors measure and report a set of features that characterize the energy being sensed from an object. These reports are compared against previous reports in order to ascertain that the current energy is from the same object as in a previous report. This process is sometimes called target re-acquisition. The process is complicated, however, by the fact that the features that should be used depend upon the class of the object – e.g., class of ship, boat, or plane. If there are, say, ten features, features numbers 1, 2, and 5 might be useful for one class and features 2, 5, 6, and 10 for another. It has been found that each feature is important for some class, but that for no class are all features important. The sensor, of course, does not know the class and so reports all features. Using all available features for any given class has been found to degrade target re-acquisition algorithms. The problem is to determine which features will most likely be useful for a new class. To do this, one must first determine how many clusters there are in the feature space for the class. This determination is currently an analyst-intensive process. A subject matter expert will pour over reports known or assumed to be from a new class and will estimate which features are important and which are not. With the reduced number of Navy analysts and the expanded range of objects with which they must deal, this is no longer an option.

The sensor algorithms and the sensed object are not always as well behaved as an algorithmist might wish. Some of the features are continuous variables, some discrete. For each of the former, the sensor will also report a standard deviation of the measurement. Consecutive reports about one object may have differences in the reported measurements and the associated standard deviations. The differences may be caused by non-Gaussian noise, may be caused by the sensed object itself having a multi-modal distribution, or may be caused by sensor algorithms not processing the data properly. Finally, feature measurements are often missing or incomplete, due to excessive noise or interference.

The AFE will be a DII COE software segment within the Cryptologic Unified Build (CUB) software baseline. This topic will address technology between maritime sensors and the intelligence producing analysis and management support system for the Ship's Signal Exploitation Equipment (SSEE) program.

PHASE I: Research clustering algorithms to deal with: 1) an unknown number of clusters; 2) clusters with sizes differing both in number and statistical distributions; 2) sample sets in which only some samples have identification labels, but not necessarily correct labels; 3) a high percentage of missing feature data; and 4) computational efficiency. Review and evaluate methods of evaluating the individual features and graphically displaying results to an operator, generally one with a high school education. Since there are possibly ten dimensions to be displayed, we anticipate that the analysis

would lead to: 1) determining circumstances under which three features would be sufficient; 2) determining that at most three eigenvectors would be sufficient; or 3) developing a method of visually and easily viewing the ten-dimensional feature space two or three dimensions at a time. The goal of Phase I is to identify the algorithm or algorithms which would best handle the sensor data under consideration.

PHASE II: Develop, evaluate, and demonstrate the algorithms selected from Phase I. Estimate computational efficiency and convergence properties. Test the algorithms using: 1) historical data which has previously been analyzed by a subject matter expert; and 2) operational data which had not previously been analyzed. Evaluate the robustness and consistency of the algorithms by repeated testing using sample sets with modified measurements or labels. Demonstrate that the AFE could perform at least as well as an experienced Navy analyst. The demonstration will be in the context of the Cryptologic Management and Analysis Support System of SSEE Increment E.

PHASE III: Integrated the AFE DII COE CUB segment to SSEE baseline.

COMMERCIAL POTENTIAL: Other DoD services and national agencies also have automated sensor systems, potentially high volumes of intercept reports, and limited manpower for analysis. AFE would be of interest to the Army, Marine Corps, Air Force, and the deep water Coast Guard. The AFE could also be useful for any company that collects and wishes to use information on, say, customers but which does not always collect the name or other identifier of the customer. The information that is useful for customer re-identification could depend on the class – e.g., age, vocation, and education – of the customer. The AFE could be used to evaluate which data fields might best be used to associate the current, unnamed, customer with those of previous visits.

REFERENCES:

1. Numerous textbooks and journal articles on pattern recognition and expert systems address many of the relevant subjects, but none addresses the combination needed here.

KEYWORDS: Clustering, Expert Systems, Feature Space Partitioning, Composite Classifiers, Dynamic Modeling, Target Re-Acquisition

N02-112 TITLE: Smart Signal Parser (SSP) and Actionable Intelligence Extraction (AIE)

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT III: PMW 189– Naval Electronic Combat Surveillance Systems

OBJECTIVE: The decision process inherent in acquiring knowledge and deriving actionable (relevant and timely) intelligence based on classic, manual communications intelligence is daunting and clumsy when applied to dense communications environments found in the littoral battlespace. The objective of this task is to develop a rules based agent, the Smart Signal Parser (SSP), to sort and assign recognized signals of interest (SOI) to processing agents designed to automatically extract timely and relevant knowledge and intelligence. Another functionality of this rules based intelligent agent, termed Actionable Intelligence Extractor (AIE), will automatically produce actionable intelligence products and tactical knowledge from the internals of parsed digital, voice or computer-computer messages. Multiple AIEs (assigned to different SOI "sub-sets") will interoperate (combinational problem solving) to combine and relate information from all signals (message internals) as a total group in order to produce the desired actionable intelligence. The results are based on Key Decision Factors (KDF), which are established by the user representing his/her actionable intelligence needs, and on the rules based actionable intelligence extraction processes. For example, KDFs could address intelligence of interest such as intentions, location, movement, size of group, readiness, plans, vulnerabilities, etc.

DESCRIPTION: To be successful in extracting select, high-value actionable intelligence from high-density Information Warfare signal environments while reducing manpower requirements, Cryptologic intelligence collection systems must have a high degree of automation at all stages of processing. These systems, whether military (Navy, Army or Air Force)

or civilian (FBI, DIA, police, etc.), all have considerable similarity. They search, detect, Direction Find (DF), recognize signals of interest. In the next stages of processing, they produce meaningful text, voice, etc from which the message information is determined, usually by an analyst who produces a report. In wideband systems, the end-to-end process is performed automatically. In narrowband systems, much is done manually. However, regardless of whether the system is wideband or narrowband, actionable intelligence and knowledge extraction is largely a manual, often separate process, which is seldom timely and often not completed. To the tactical commander or agent/officer in the field, this is unacceptable.

The SSP will address signal parsing/sorting but also provide the automatic control necessary for knowledge extraction and knowledgebase management. The Phase I design process and Phase II prototyping will produce a capability incorporating multiple techniques/algorithms and rules, including expert rules, in order to extract the desired intelligence/knowledge. Timeliness needs will be served by taking advantage of automated initial indications monitoring and smart processes/decision making in order to quickly cull the problem set. In addition, parallel processing will be used to hasten results. Parallel processing and client-server designs of many current cryptologic systems will facilitate this approach.

The Actionable Intelligence Extractor (AIE) provides, for each signal class, the final automated processing stage. The AIE will automatically associate internal (message) information, including voice, digital (text) and computer-to-computer information. This will be achieved for these types of signals by searching through message contents and correlating pre-established characteristics and/or information using algorithmic techniques. The task lies in managing a large problem set (many signal classes, numerous KDF) and the differing characteristics of the incoming raw data (low level data/information). Problems due to noise, message structure differences, processing time-bandwidth in order to extract and "compose" the desired actionable intelligence products and "tactical" knowledge. To this end, numerous processing techniques should be employed by the AIE (i.e. heuristic search, symbolic or statistical reasoning, filtering, game theory, distributed intelligence, domain knowledge based expert processing, learning systems, language process techniques, even qualitative and quantitative analysis) and allocated dynamically (by the SSP) to message "sub-sets". The "sub-sets" processing assignment is determined by the SSP and is monitored and re-evaluated based on measured success criteria. And the dynamics of the changing signal environment will require dynamic change in techniques applied to the total problem. Algorithms will be developed to determine the processing assignment (match problem "sub-sets" to best-fit solution method) and optimize the processing path through the "decision tree" (best problem logic path to follow considering all active "sub-sets"). Key to the model is to be able to measure the instantaneous problem set size and composition (based on the number and type of SOI recognized) in order to be able to properly parse the problem set and properly assign best fit processing solutions (not a single processing approach as is classically done) and processing resources. Multi-hypothesis analysis and testing will assist in this determination.

The AIEs will automatically combine message (internals) information with similar information/actionable intelligence extracted by other AIE processes (e.g. for other "sub sets") to associate relevant extracted intelligence, and consequently compound it, based on assigned KDFs and processing rules. The result is a composite set of information comprising the desired actionable intelligence sought and including recommendations for action. Recommendations for action are based on pre determined and approved actions, decided upon by higher authority in advance, and implemented only if intelligence warrants (e.g. Rules Of Engagement, agency policy and procedures, etc)). Relationships, or "information sets" will be constructed according to message contents and their associations (e.g. trends, statistics, speaker, associations, pattern recognition/transformations, dynamic inferences, activity [usage, time, durations, position/motion], etc). Rules, algorithmic solutions and initial KDFs, including a standard format, will be constructed to operate on collected SOI internals. Statistics will be collected to measure solution quality and confidence. Solution "outliers" will be dropped and used to adjust the process to minimize errors and maximize solution confidence. Associated with the resulting actionable intelligence or knowledge produced, an action may be recommended. During development, statistics will be a key tool in tuning algorithms and rules.

PHASE I: Define Signal Of Interest "sub-sets" or families. Define processing rules (static initially, then expert) and allocate to SOI "sub-sets". Develop or select/evaluate algorithms for applicability, accuracy, speed, solution quality, suitability, match, etc. in order to establish SOI "sub-sets" applicability. Define candidate KDFs. Define statistics to be collected. Define the high-level functional requirements and functional relationships (interfaces) incorporating the SSP and AIE functions with other host system functions and architecture. Determine SSP and AIE lower level functional,

interface and performance requirements and integrate all requirements analyses. Acceptable tools to use for this process include top-down object oriented design and/or structured design techniques. At the lower levels of the requirements breakdown, allocate requirements to software, hardware, and operator.

PHASE II: Perform SSP and AIE detailed software design (DII COE compliant), code, test, implement, evaluate and demonstrate in a laboratory environment. Replace fixed rules with expert rules and re-test (lab demonstration). Test with statistical data (historical or synthesized) initially followed by operational testing later in phase II (operational demonstration). As a goal, both the lab and operational demonstrations should show SSP and AIS interoperation and should incorporate appropriate components of a target operational cryptologic system, to the extent practical and sufficient. Document SSP and AIE and provide initial training materials.

PHASE III: Integrate and produce ILS resources for inserting the SSP and AIE software into the SSEE baseline.

COMMERCIAL POTENTIAL: This capability has direct benefit to other Maritime Cryptologic programs. Since SSEE is common with other Maritime and national systems, the SSP and AIE will be of interest to benefit Naval airborne and subsurface Cryptologic systems. These capabilities also will have direct benefit to the US Marine Corp, USCG and SOCOM Cryptologic Systems (which are maritime partners of the MCA). Furthermore, intelligence collecting agencies including the FBI, DIA, NSA, CIA and city law enforcement agencies could also benefit from this technology. The application of the SSP and AIE would be exactly the same for other military systems as for Naval surface cryptology. The computing environment will use NT and/or SOLARIS, is client server based, with power PC (essentially chip independent) available to support processing needs. Only COTS hardware and software will be used for the computing environment.

REFERENCES:

1. Numerous textbooks and scientific, mathematical, and engineering journal articles on optimum control, artificial intelligence, expert systems, rules based systems and pattern recognition address the mathematics and algorithms that could apply, but none completely address the combined applications required to develop the capability addressed herein.

KEYWORDS: Artificial Intelligence, Expert Systems, Optimum Control, Indications and Warnings, Feature Extraction, Pattern Recognition

N02-113 TITLE: <u>Integrated Image Processing/Geographic Information System (GIS) Process Development</u>

TECHNOLOGY AREAS: Information Systems, Battlespace, Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT IV: Naval METOC Information Systems

TECHNOLOGY AREAS: Information Systems, Human Systems, Battlespace Environment

OBJECTIVE: Design and build a software tool, or a suite of no more than three software tools, that will revolutionize the way human analysts interpret and fuse visual, analog and digital environmental data originating from civil and military environmental satellites, in-situ sensors and complex numerical models, including the development of an automated metadata generation capability for the value-added environmental information that the analysts produce. Speed of use and ease of use are key objectives for the envisioned tool technology(ies).

DESCRIPTION: The continuing development and availability of new environmental satellite and battlespace in-situ sensors and more complex numerical models of the earth's atmosphere and oceans severely challenges the human analysts' cognitive abilities to integrate and to interpret rapidly the wealth of visual information that might be derived from these sources. Ultimately, the analysts use this data to produce the value-added information that is intended to meet their customers' decision-making needs. Although there are a multitude of commercial GIS technologies available for a variety of commercial and military users today, there is no one software tool, or small set of tools, that provides the capability that human analysts need to produce their value-added environmental information rapidly for their customers

and that automatically generates useful metadata.

PHASE I: Develop an overall system engineering design that includes specification of the software tool technology, specification of the input environmental sensors and models, specification of the GIS technology, specification of the automated metadata, and specification of the interfaces for the proposed tool technology(ies) - including the human interface specification. Provide a technical report on the system design, including proposed performance metrics.

PHASE II: Develop and demonstrate the prototype technologies for a small set of user applications. Provide a short technical report on the demonstration results.

PHASE III: Conduct testing to prove the feasibility of the technologies for a more robust set of commercial applications during an extended operating period. Provide a technical report on the demonstration, including demonstrated performance metrics.

COMMERCIAL POTENTIAL: This system could be used in a broad range of commercial applications where the rapid interpretation and registration of environmental data with geographic features are necessary - for example, by military analysts in monitoring the battlespace environment in various regions around the world, and by civilian/commercial users in detecting and monitoring local environmental conditions that might be potentially hazardous to the general public.

KEYWORDS: GIS, Visual Data, Environmental Data, Data Fusion, Metadata

N02-114 TITLE: Broadband/Multi-band Reflector Antenna Feeds Supporting X, Ku, K, Ka, and Q Frequency Bands.

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: ACAT III/IV: PMW173-31 Submarine Communications

OBJECTIVE: Develop broadband/multi-band reflector antenna feeds that operates at the X, Ku, K, Ka, and Q frequency bands and possibly subsets of these frequency bands. The reflector antenna feeds must be designed to be compatible with existing submarine mast antennas.

DESCRIPTION: Presently the Navy has a High Data Rate (HDR) SATCOM system that has the capabilities of EHF: Q and k -bands, and SHF: x-band. A suitable design requirement is necessary to cover the X, Ku, K, Ka, and Q frequency bands of operation.

Investigation into the development of a single element broadband/multi-band reflector antenna feed which can support all frequency bands is desired with the capability of allowing a change out of the antenna feed system to occur without physical access. The focus for this proposal is to develop broadband/multi-band reflector antenna feeds that operate at the x, ku, k, ka, and Q frequency bands and possibly subsets of these frequency bands. The reflector antenna feeds must be designed to be compatible with existing submarine mast antennas.

PHASE I: Broadband reflector antenna feeds are available for a small range of frequencies. The need exists for increasing the capability of the feed for additional frequencies, namely, the Ku and Ka band frequencies. Initial work in phase I requires the detailed development of a broadband or a multi-band reflector antenna feed system to be compatible with existing submarine mast antennas. Conceptual design descriptions will be provided with supporting detailed theoretical data. Designed antenna feed elements shall be modeled using the current state-of-the art computer programs or theoretically modeled to demonstrate effectiveness.

PHASE II: Detailed design data of the reflector antenna feed system will be presented. A prototype will be fabricated to demonstrate concept feasibility. All operational tests; including EM, mechanical, stress, and pressure testing, will be

performed with the prototype antenna feed system. Demonstration of the ability of the antenna feed system to survive in a submarine environment will be made. All data results will be tabulated and presented in a technical white paper.

PHASE III: Fabrication of the antenna feed system will be made and integrated into an existing submarine mast antenna. Performance of necessary EM tests with antenna feed system and submarine mast antenna will be made to prove compatibility and design success.

COMMERCIAL POTENTIAL: All broadband/multi-band reflector feed commercial applications would benefit from this technology development.

REFERENCES:
1. Microwave Horns and Feeds, A.D. Olver, P.J.B. Clarricoats, A.A. Kishk, and L. Shafai, Institute of Electrical and Electronic Engineers, Inc. New York, USA, 1994

KEYWORDS: Antenna Feeds, Reflector Antenna Feeds, Reflector Antennas, Antenna Design, RF Design, Dielectric Feeds

AIR FORCE
SMALL BUSINESS INNOVATION RESEARCH
PROPOSAL PREPARATION INSTRUCTIONS

The Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio, is responsible for the implementation and management of the Air Force SBIR Program. The Air Force SBIR Program Manager is Mr. Steve Guilfoos, 1-800-222-0336. Do not submit SBIR proposals to the AF SBIR Program Manager under any circumstances. All questions concerning proposal submissions, Fast Track applications and requirements, and award/contracting issues should be directed to the appropriate agency SBIR Program Manager listed beginning page AF-5. Addresses for proposal submission and numbers for administrative and contracting questions are listed on the following pages, AF-5 through AF-215.

Technical questions may be submitted directly to the topic author prior to December 1, 2001, or after that using the DTIC SBIR Interactive Technical Information System (SITIS). For a full description of this and other technical information assistance systems from DTIC, please refer to section 7.1 of this solicitation.

Air Force Nine-Month Phase I Contract

For the Air Force, the contractual period of performance for Phase I shall be nine (9) months, and the price should not exceed $100,000. Only one cost proposal for the entire nine month contractual period of performance will be accepted.

The Phase I award winners must accomplish their primary research during the first six months of the contract. This primary research effort, alone, is used to determine whether the AF will request a Phase II proposal. We anticipate no more than 80% of the total cost should be expended within the first six months. After the first six months, additional related research should further the Phase I effort and put the small business in a better position to start Phase II, if awarded.

The last three months of the nine-month Phase I contract will provide project continuity for all Air Force Phase II award winners so that no modification to the Phase I contract should be necessary. The Air Force will accept proposals for modifications to maintain project continuity under special circumstances such as Fast Track.

Air Force Phase I and Phase II Evaluation

Our evaluation of the primary research effort and the proposal will be based on the factors listed in Section 4 of the solicitation; a) the soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution; b) the qualifications of the proposed principal/key investigators, supporting staff, and consultants (qualifications include not only the ability to perform the research and development but also the ability to commercialize the results) and c) the potential for commercial (government or private sector) application and the benefits expected to accrue from this commercialization. The actual assigned weightings will not be disclosed outside of the DoD. Please note that where technical evaluations are essentially equal in merit, and as cost and/or price is a substantial factor, cost to the government will be considered in determining the successful offeror.

NOTICE: Only government personnel will evaluate proposals. However, base support contractors may be used to monitor contract performance and testing. Any contract award may require a nondisclosure agreement between base support contractors and awarded small businesses.

You must receive a written invitation before submitting a Phase II proposal. All Fast Track applicants may submit a Phase II proposal prior to receiving a formal invitation letter. The Air Force will select Phase II winners based solely upon the merits of the proposal submitted, including Fast Track applicants.

Air Force Phase I Proposals

Phase I proposals shall reflect a nine month effort that should not exceed $100,000. Remember, the first six months constitutes the primary research effort and will be used to evaluate whether a Phase II proposal will be requested.
Proposals are limited to 25 pages, excluding Company Commercialization Report.

Air Force Phase II Proposals

Phase II proposals are typically 24 months in duration not exceeding $750,000. The Air Force anticipates that pricing will be based on adequate price competition. Phase II Instructions from the sponsoring Air Force organization will specify the number of proposal pages (typically 75). However, if the Air Force selects your company to receive an award, be prepared to submit further documentation to substantiate costs. This further information is necessary to facilitate the contracting process.

Air Force Phase II and Fast Track

Detailed instructions on the Air Force Phase II program and notification of the opportunity to submit a fast track application will be forwarded to all Phase I awardees by the awarding Air Force organization at the time of the Phase I contract award. The Air Force encourages businesses to consider a Fast Track application when they can attract outside funding and the technology is mature enough to be ready for application following successful completion of the Phase II contract. For Fast Track applicants, should the outside funding not become available by the time designated by the awarding Air Force activity, the offerer will not be considered for any Phase II award.

Air Force Phase II Enhancement Program

On active phase II awards, the Air Force will invite a limited number of Phase II awardees to apply and compete for a Phase II Enhancement to address new unforeseen technology barriers that were discovered during the Phase II work. The selected enhancements will extend the existing Phase II contract award for up to one year and the Air Force will match dollar for dollar up to $250,000 of non-SBIR DoD matching funds.

Air Force Commercial Potential Evidence

An offeror needs to document their Phase I or II proposal's commercial potential as follows: 1) the small business concern's record of commercializing SBIR or other research, particularly as reflected in its Company Commercialization Report (www.DoD.sbir.net/companycommercialization); 2) the existence of second phase funding commitments from private sector or non-SBIR funding sources; 3) the existence of third phase follow-on commitments for the subject of the research and 4) the presence of other indicators of commercial potential of the idea, including the small business' commercialization strategy.

Air Force SBIR Program Management Improvements

The Air Force reserves the right to modify the submission requirements. Should the requirements change, all Phase I awardees who are invited to submit Phase II proposals will be notified. The Air Force also reserves the right to change any administrative procedures at any time that will improve management of the Air Force SBIR Program.

Air Force Submission of Final Reports

All final reports will be submitted to the sponsoring Air Force agency. **Companies should not** submit final reports directly to DTIC.

Proposal Submission Instructions

Your proposal will be ACCEPTED if you meet all of the following criteria. Failure to meet any one of the criteria will result in your proposal being REJECTED.

1. The Air Force Phase I proposal shall be a nine month effort and the cost shall not exceed $100,000.

The Air Force will not accept any proposals that have not electronically submitted the Proposal Cover Sheet (http://www.dodsbir.net/submission). The electronic forms submitted must match the paper copies submitted via mail, express, or hand delivery.

3. A copy of the Company Commercialization Report with summary page prepared on the Submission site must be submitted with all proposals. (See Section 3.4n. of the solicitation.) Even if you have no Phase I or Phase II information to report, you must submit a Company Commercialization Report. Your proposal will not be penalized in the evaluation process if your company has never had any SBIR Phase I's or II's in the past.

4. Both the electronic submission of the Proposal Cover Sheet and the paper copies of your proposal must be received on or before the deadline. The Air Force will not accept late proposals, or incomplete proposals. If you have any questions or problems with submission of your proposal allow yourself time to contact the Air Force activity and get an answer to your question. Submit the Electronic Proposal Cover Sheet and Company Commercialization Report early, as server traffic increases, server response slows down. Do not wait until the last minute. The Air Force will not be responsible for late proposals caused by servers being "down" or inaccessible.

Electronic Submission:

Prepare your SBIR proposal to the Air Force using the DoD Electronic Submission Web Site at **http://www.dodsbir.net/submission**. This site allows your company to come in at any time (prior to the closing of the solicitation) to add, edit or print out your Proposal Cover Sheet and Company Commercialization Report. The Air Force will not accept any Proposal Cover Sheet or Company Commercialization Report except those from the Electronic Submission Web Site as valid proposal submission forms.

*** Note: The Air Force period of performance for Phase I is nine months.**

Once you have prepared, printed, and signed the Proposal Cover Sheet and Company Commercialization Report, mail it along with one original and four copies of your entire proposal (the copies should include four copies of the signed Proposal Cover Sheet) to the appropriate Air Force offices at the addresses listed below.

PHASE I PROPOSAL SUBMISSION CHECKLIST:

All of the following criteria must be met or your proposal will be REJECTED.

____1. Your Phase I Proposal Cover Sheet submitted electronically on the Submission site.

____2. Your Company Commercialization Report submitted electronically on the Submission site.

____3. Your Cost Proposal does not exceed $100,000 and the period of performance is 9 months.

____4. Your entire proposal is 25 pages or less, excluding the Company Commercialization Report.

____5. A signed copy of the Proposal Cover Sheet and Company Commercialization Report are attached to the technical and cost proposal.

____6. One original and four copies of your entire proposal are mailed to the appropriate Air Force office and received by January 16, 2002.

PROPOSAL SUBMISSION INSTRUCTIONS

For each Phase I proposal, both the electronic submission of Appendix A and B and the paper copies (original and 4 copies) of your proposal must be sent to the office designated below. Be advised that any overnight delivery may not reach the appropriate desk within one day. Be sure to read the Air Force instructions on the previous page for the nine-month Phase I contract to avoid the rejection of your proposal. To request notification of proposal receipt, send request (Ref A on page Ref 1) with a self-addressed stamped envelope. Do not call to ask whether your proposal has been received; due to time constraints, we will not be able to answer such telephone calls.

TOPIC NUMBER	ACTIVITY/MAILING ADDRESS	CONTRACTING AUTHORITY
	(Name and number for mailing proposals and for administrative questions)	(For contract questions only)
AF02-001 thru AF02-003 AF02-005 thru AF02-013 AF02-015 AF02-017 thru AF02-023	Directed Energy Directorate AFRL/DE 3600 Hamilton Avenue SE Bldg 382 Kirtland AFB NM 87117-5776 (Robert Hancock, (505) 846-4418)	Dave Tuttle (505) 846-8133
AF02-004 AF02-025, AF02-031 AF02-033 thru AF02-046 AF02-050 thru AF02-052 AF02-054, AF02-055 AF02-057, AF02-059, AF02-060 AF02-062, AF02-063	Space Vehicles Directorate AFRL/VS 3600 Hamilton Avenue SE Bldg 382 Kirtland AFB NM 87117-5776 (Robert Hancock, (505) 846-4418)	Francisco Tapia (505) 846-5021
AF02-032, AF02-048 AF02-058, AF02-064	Space Vehicles Directorate AFRL/VSOT 29 Randolph Road Hanscom AFB MA 01731-3010 (Noreen Dimond, (781) 377-3608)	John Flaherty (781) 377-2529
AF02-067 thru AF02-073 AF02-078 AF02-080 thru AF02-085	Human Effectiveness Directorate AFRL/HEOP 2610 Seventh Street, Bldg 441, Rm 216 Wright-Patterson AFB OH 45433-7901 (Sabrina Davis, (937) 255-2423 x226)	Mary Jones (937) 255-2527
AF02-089 thru AF02-094 AF02-096 AF02-099 thru AF02-104 AF02-106 thru AF02-110	Information Directorate AFRL/IFB 26 Electronic Parkway Rome NY 13441-4514 (Jan Norelli, (315) 330-3311)	Joetta Bernhard (315) 330-2308
AF02-111 thru AF02-126 AF02-128 thru AF02-134	Materials & Manufacturing Directorate AFRL/MLOP 2977 P Street, Bldg 653, Suite 13 Wright-Patterson AFB OH 45433-7746 (Marvin Gale, (937) 255-4839)	Terry Rogers (937) 656-9001

AF02-138 AF02-141 thru AF02-147 AF02-149 thru AF02-153 AF02-155, AF02-157 AF02-159, AF02-160 AF02-163 AF02-166 thru AF02-171	Munitions Directorate AFRL/MNOB 101 W Eglin Blvd, Suite 140 Eglin AFB FL 32542-6810 (Richard Bixby, (850) 882-8591 x1281)	Selesta Abbott (850) 882-4294 x3414 Linda Weisz (850) 882-2872
AF02-175 thru AF02-179 AF02-181 thru AF02-188 AF02-190	Propulsion Directorate AFRL/PROP 1950 Fifth Street, Bldg 18 Wright-Patterson AFB OH 45433-7251 (Dottie Zobrist, (937) 255-6024)	Susan L. Day (937) 255-5499 X067
AF02-191 thru AF02-194	Propulsion Directorate AFRL/PROP 5 Pollux Drive Edwards AFB CA 93524-7033 (Debbie Spotts, (661) 275-5617)	Donna Thomason (661) 277-8596
AF02-196 thru AF02-202 AF02-204 thru AF02-206 AF02-208, AF02-209 AF02-211 thru AF02-215 AF02-218, AF02-219 AF02-221 thru AF02-224 AF02-227 thru AF02-229 AF02-232 thru AF02-237	Sensors Directorate AFRL/SNOX 2241 Avionics Circle, Bldg 620 Wright-Paterson AFB OH 45433-7320 (Marleen Fannin, (937) 255-5285 x4117)	John Stovall (937) 255-5380 x097
AF02-242 thru AF02-248 AF02-250, AF02-251 AF02-253 thru AF02-257 AF02-259	Air Vehicles Directorate AFRL/VAOP 2130 Eighth Street, Bldg 45, Rm 149 Wright-Patterson AFB OH 45433-7542 (Madie Tillman, (937) 255-5066)	Capt Bill Surrey (937) 255-5901
AF02-263 thru AF02-264	Oklahoma City ALC OC-ALC/TIET 3001 Staff Drive, Suite 2AG70A Tinker AFB OK 73145-3040 (Bill Tilley, (405) 736-3990)	David Cricklin (405) 739-4468
AF02-265 thru AF02-270 AF02-272	Ogden ALC OO-ALC/TIEH 5851 F Avenue, Bldg 849, Rm A-15 Hill AFB UT 84056-5713 (Bill Wassink/Joe Burns, (801) 777-2977)	Martha Scott (801) 777-0199
AF02-276 thru AF02-282	Warner Robins ALC WR-ALC/TIECT 420 Richard Ray Blvd, Suite 100 Robins AFB GA 31098-1640 (Jamie McClain, (478) 926-6617)	Ken Burke (912) 926-3695

AF02-283 thru AF02-284 AF02-286 thru AF02-288 AF02-291	Air Armament Center 46 TW/XPP 101 W. D Avenue, Suite 222 Eglin AFB FL 32542-5492 (Cosmo Calobrisi, (850) 882-6434)	Lorna Tedder (850) 882-4141 x4557
AF02-292 thru AF02-298	Arnold Engineering Development Center AEDC/DOT 1099 Avenue C Arnold AFB TN 37389-9011 (Ron Bishel, (931) 454-7734)	Kathy Swanson (931) 454-4409
AF02-301 thru AF02-307	Air Force Flight Test Center AFFTC/XPST 307 East Popson Avenue Bldg. 1700, Rm 107A Edwards AFB CA 93524-6843 (Abe Atachbarian, (661) 277-5946)	Donna Thomason (661) 277-5946

Air Force 02.1 SBIR Topics

DIRECTED ENERGY DIRECTARATE, KIRTLAND AFB

AF02-001	Ultra-Wideband (UWB) Target Identification
AF02-002	Optical Systems Fault Management
AF02-003	Drilling 170 Micron Diameter Holes
AF02-005	Frequency-Agile Monolithic Micro-Laser with Ultra-Narrow Linewidth
AF02-006	Solid State Low Energy Lasers for Space Based Lasers
AF02-007	High Energy Laser Diagnostics for Space Based Applications
AF02-008	Active In-Situ Contamination Control
AF02-009	High Temporal and Spatial Resolution Laser Beam Diagnostic Sensor
AF02-010	High Temperature Target Failure Sensor
AF02-011	New Thermal Sensors for Use with Inverse Heat Conduction Problems
AF02-012	Active Target Tracking through Deep Atmospheric Turbulence
AF02-013	Develop Coatings that Repel Contamination
AF02-015	All-Optical High-Energy-Laser Beam Control
AF02-017	Coatings for Large, Lightweight, Compliant, and Scalable Deployable Space Optics
AF02-018	Application of Quantum Cascade Lasers to High Explosive Detection
AF02-019	Real Time Adaptive Signal Processors for On-line Performance Optimization of Adaptive Optical Systems
AF02-020	Tracking Through Laser-Induced Clutter for Air to Ground Directed Energy Systems
AF02-021	Periodically Poled Stoichiometric Lithium Tantalate for Nonlinear Optical Frequency Conversion
AF02-022	Artificial Dielectrics for High Power Microwave Applications
AF02-023	Grating Surface Emitting Semiconductor Laser Incoherent Array with High Average Power

SPACE VEHICLES DIRECTORATE, KIRTLAND AFB

AF02-004	Beam Train Flexible Structure Control for Airborne/Space-Based Systems
AF02-025	Novel Low-Noise Extra High Frequency Amplifiers
AF02-026	Dynamic DC Source and Load System with Energy Recycle Capability
AF02-027	Multifunction Phase Array Antennas
AF02-028	Next-Generation 35-40% Efficient Multijunction Solar Cell
AF02-029	Phased Array Antenna Power Amplifier Modules
AF02-030	Miniature Traveling Wave Tubes for Space Application
AF02-031	Lightweight Primary Mirror Technology
AF02-033	Power Efficient Space Computer
AF02-034	High Temperature Polymer Substrate for Thin Film Solar Cells
AF02-035	Reconfigurable Logic for Space
AF02-036	Multi-functional Polymer Optical Interconnect Technologies for Wireless Satellite Data Communications
AF02-037	Novel High Current Switch for Spacecraft Power Bus Control
AF02-038	Integrated Thin Film Solar Array and Phased Array Antenna
AF02-039	High Efficiency Non-Vacuum Processed Thin-Film Photovoltaics
AF02-040	Parallel-Connected Converters with Innovative Control
AF02-041	Advanced 10 Kelvin Cryogenic Cooling Technology
AF02-042	Advanced Component Technology for Next Generation Cryocoolers
AF02-043	Advanced Multi-stage Cryogenic Cooling Technology
AF02-044	Advanced Thermal Integration Technology for Space Cryocoolers
AF02-045	Large Focal Plane Array Cryogenic Integration Technology
AF02-046	High-Performance HgCdTe VLWIR Photovoltaic Detectors
AF02-050	Small Launch Vehicle Technology
AF02-051	Small Shuttle-Compatible Propulsion Module
AF02-052	Payload Adapter for Satellite Missions Launched using ICBM-derived Launch Vehicles
AF02-054	Insulated Stainless Steel or Molybdenum Substrate for Thin Film Photovoltaics
AF02-055	Star Trackers Based Upon Advanced Sensor Technologies
AF02-057	Polarization Phenomenology Modeling and Simulation
AF02-059	Smart Membrane Structures
AF02-060	Long-Stroke Isolation System for Large Flexible Space Structures
AF02-062	Autonomous Satellite Cluster Data Fusion
AF02-063	Remote Satellite Diagnostics

SPACE VEHICLE DIRECTORATE, HANSCOM AFB

AF02-032	Electrodynamics of the High-Latitude Ionosphere
AF02-048	Advanced Algorithms for Exploitation of Space-Based Imagery
AF02-058	Geophysical Interpretation of Digital Ionosonde Signatures
AF02-064	Ground-based Daytime Optical Imaging of the Ionosphere

HUMAN EFFECTIVENESS DIRECTORATE, WRIGHT-PATTERSON AFB

AF02-067	Deployable Ceramic Oxygen System
AF02-068	DMT Training Requirements and Capability Analysis
AF02-069	Aircrew Bladder Relief Capability
AF02-070	Time Critical Targeting Cell (TCTC) for Team Training and Evaluation
AF02-071	Distributed Interactive Training for the C2 Aerospace Operations Center (AOC)
AF02-072	Integrated Satellite Operations Training and Rehearsal for Multiple Satellite System Ground Control
AF02-073	Advanced Runway Lighting Technology for Portable Applications
AF02-078	Messaging Interaction Simulation
AF02-080	Imagery Manipulation for Simulator Databases
AF02-081	Advanced 50 dB Hearing Protective/Voice Communication System for 150 dB Noise
AF02-082	Viewer for Vision Research in Developing Agile Laser Eye Protection
AF02-083	Fatigue Assessment through Voice Analysis
AF02-084	Robotic cRNA Processing System for Gene Microarray Analysis
AF02-085	Adaptive Training for Real-Time Intelligence Monitoring & Evaluation

INFORMATION DIRECTORATE, ROME NY

AF02-089	Enhanced Interoperability Through Common Translation Architecture
AF02-090	Data Link Common Software for Multiple Link-16 Applications
AF02-091	Innovative Method for Performance & Mission Worth Analysis of Integrated Command and Control Systems
AF02-092	Portable Universal Ground Processing Unit
AF02-093	Lightweight, Highly Deployable, Jam-resistant Satellite Communications Modem
AF02-094	Signal Diversity Combining for Improved Satellite Communications
AF02-096	JAVA-Based, Performance Oriented Visualization System
AF02-099	Data Mining of GMTI Databases
AF02-100	Coordinating Multiple Airborne Platforms to Improve Targeting Accuracy
AF02-101	Feature Aided Tracking (FAT) to Augment Track Continuity
AF02-102	Spectral Filtering
AF02-103	Innovative Information Technologies
AF02-104	Innovative Approaches for Information Fusion
AF02-106	Quantum Information Science
AF02-107	HPC for C2 Decision Support
AF02-108	Configurable Enterprise Test Harness for Publish and Subscribe Architectures
AF02-109	Multisensory Assimilation of Complex C2 Information
AF02-110	Secure Peer-to-Peer Object Repository

MATERIALS & MANUFACTURING DIRECTORATE, WRITE-PATTERSON AFB

AF02-111	Casting Hard Alpha Inclusion Detection
AF02-112	Lightweight Titanium Heat Exchangers
AF02-113	Component Surface Treatments for Engine Fatigue Enhancement
AF02-114	Corrosion Preventative Coatings
AF02-115	Superlattice Materials for Very-Long Wavelength Infrared Detectors (VLWIR)
AF02-116	Conductive Resin Systems for Aircraft Composite Structures
AF02-117	Tamper Resistant Coating Development
AF02-118	Secure Circuit Board Materials and Processes
AF02-119	Tailored Adhesives for Damage Tolerant Joints
AF02-120	Qualifying Light, High-Performance Materials for Airborne Expeditionary Forces (AEF)
AF02-121	Use of Alternate Materials for Infrared (IR) Missile Domes
AF02-122	Individual Plastic Component Water Sealing
AF02-123	Innovative Approaches in Secure Hardware
AF02-124	Demonstration of Compound Semiconductor Films on a Compliant Substrate
AF02-125	Crack Growth Behavior of Hard Alpha Inclusions in Titanium Castings
AF02-126	Verification of Composite Bonded Joint Integrity

AF02-128	Logistic Fuel Sulfur Removal for Fuel Cell Use in Air Expeditionary Force (AEF) Operations
AF02-129	Advanced Materials for Lightweight Space-Based Mirrors
AF02-130	Dynamic Filtering of MidWave InfraRed (MWIR) Radiation
AF02-131	Novel Materials for Spacecraft Thermal Control Coatings Technologies
AF02-132	Polymer Claddings for Space Photonics
AF02-133	Multifunctional Thermally and Electrically Conductive Carbon Nanotube-Polymer Hybrid Material
AF02-134	Virtual Nondestructive Evaluation (NDE): Computational Methods for Virtual Prototyping

MUNTIONS DIRECTORATE, EGLIN AFB

AF02-138	Distributive Processing Techniques For Interconnected Embedded Systems
AF02-141	Micro Air Vehicles for Munition Bomb Damage Indication
AF02-142	Bomb Impact Analysis and Damage Assessment via Remote Sensor
AF02-143	Effects of Internal Weapons Bays on Advanced Munitions
AF02-144	Reconfigurable Computing Applications for Aircraft, Munitions and Dispensers
AF02-145	Liquid Payload Expulsion and Aerosolization
AF02-146	The use of synthetic aperture radar (SAR) imagery for targeting of Laser Radar terminal seekers
AF02-147	Improvement of Penetrator Performance by Increasing/Engineering Case Mechanical Properties
AF02-149	Agent Defeat Short Time Neutralization Data Collection and Modeling
AF02-150	Low Cost Universal Flight Termination System
AF02-151	Use of Kalman Filter Residuals for Independent Fuze Safeing
AF02-152	Intraweapon Wireless Communication
AF02-153	Innovative Sensor Precision Guided Munition Accuracy
AF02-155	Automatic 3-Dimensional Wire-Frame Model Generation Algorithm
AF02-157	Zero-Zero Target Sensor
AF02-159	Munition Thermal Management
AF02-160	Low Cost Manufacturing of Range Extension Wing Kits
AF02-163	Development of Structural Explosives for Low Collateral Damage (LCD) Warheads
AF02-166	Munitions Research
AF02-167	Miniature Initiation System Technology (MIST)
AF02-168	Enhanced Laser RADAR Through Augmenting Signal Information Content
AF02-169	Navigation Solutions by Terrain Imaging
AF02-170	Positron Energy Conversion Based Weapons
AF02-171	Biomimetic Concepts for Situational Awareness

PROPULSION DIRECTORATE, WRIGHT-PATTERSON AFB

AF02-175	Aero Propulsion and Power Technology
AF02-176	Improved Composite Duct Design for Increased Safety Margin or Weight Reduction
AF02-177	Innovative Onboard Power and Cooling Solutions
AF02-178	Fuel Additives For Reduced Engine Emissions
AF02-179	Fuel Tank Compatible Oxygen Sensor
AF02-181	Fuel Tank Ullage Oxygen Sensor for Live-Fire Ballistic Testing
AF02-182	Advanced Vibration Monitoring Diagnostics and Prognostics Techniques
AF02-183	Small, Low Cost, High Performance Engines for Miniature Munitions
AF02-184	Global Reach High-Speed air Vehicles and Weapons
AF02-185	Technologies for Air Breathing Propulsion
AF02-186	High Heat Flux Laser Diode and/or Solid State Laser Cooling for Airborne and/or Spaceborne Directed Energy Applications
AF02-187	Ultra-wide bandwidth high-power solid state photoconductive power switch technology
AF02-188	Health Monitoring for the Integrity of Electrical Power Wiring and Power System Components
AF02-190	Improved Composite Front Frame for Weight and Cost Reduction

PROPULSION DIRECTORATE, EDWARDS AFB

AF02-191	Advanced Rocket Propulsion Technologies
AF02-192	Air-slew Package for Air-launched Missiles
AF02-193	Significant Improvements in High Temperature Resins for Solid Rocket Motor (SRM) Boost and Orbit Transfer Composite Cases
AF02-194	Determination of Composite Motor Case Damage

SENSORS DIRECTORATE, WRIGHT-PATTERSON AFB

AF02-196	Multi-Sensor Data Exploitation Capability
AF02-197	Digital Beamforming Transmit Subarray With Waveform Agility
AF02-198	Improved Inertial Reference Transfer Unit (IRTU) - Gyros, Mounts, Models
AF02-199	Improved UHF Antenna
AF02-200	Continuous Track and ID Fusion (CTIF)
AF02-201	High-Efficiency Amplifiers with Discretely Variable Output Power
AF02-202	Low Mass, Low Power, Digital Beamforming (DBF) Subarray for Satellite Applications
AF02-204	Simulator Technologies for Rapid Prototyping of Advanced Receiver/Processor
AF02-205	Efficient Luneberg Lens for Multi-frequency SATCOM Antenna
AF02-206	High Performance Atomic Clocks for Space
AF02-208	Global Positioning System/Inertial Measurement Unit Ultra-Tightly Coupled Integrity Monitoring
AF02-209	Innovative Sensors and Algorithms for Detection and Identification of time critical targets
AF02-211	3-D Reconstruction for Missile Recognition
AF02-212	Dual-Use Visualization Tools For Aircraft System/Subsystem Performance Assessments
AF02-213	Material and Component Development for Millimeter(MM)-Wave Imaging Systems
AF02-214	140 GHz Imaging Technology
AF02-215	Real Time Sensor Image Fusion
AF02-218	Network Multiple frame Data Association
AF02-219	Environmentally Driven Signal Processing Technology for Overland Height Finding
AF02-221	Improved Pose Estimation for Tracking and Identification Systems
AF02-222	Fusion-Aided Continuous ID for Targeting (FACIT)
AF02-223	Coupled Tracker and Identification Algorithms
AF02-224	Multiple Database Evidence Accrual Techniques
AF02-227	Ultra-Wide Band Perimeter Surveillance Sensor
AF02-228	Move-Stop-Move Signature-Aided Tracking
AF02-229	Analog to Digital Coverters
AF02-232	Accurate Computational Electromagnetics (CEM) Techniques for High Frequency Applications
AF02-233	Integrated Electro-Optical and Radio-Frequency Aperture
AF02-234	Truth Quest: Enabling Operational/Exercise Data
AF02-235	Opportunistic Sensor Resource Management for Extended Operating Conditions
AF02-236	Novel Concepts for Multi-Mission Radar
AF02-237	Innovative Phenomenology Characterization and Advanced Algorithms

AIR VEHICLES DIRECTORATE, WRIGHT-PATTERSON AFB

AF02-242	Variable Speed Aerial Refueling Drogue
AF02-243	Logistics and Maintenance System Model Development and Integration into Real-Time Mission Level Simulation Environment
AF02-244	Rapid Fatigue Life Projection for Thermal and Acoustic Loads
AF02-245	Crack-Growth Methodologies for Cold-Worked Fastener Holes in Aluminum and Titanium Alloys
AF02-246	Lightning Protection of Revolving Aircraft Turrets
AF02-247	Supportable Sandwich Control Surfaces
AF02-248	Structurally Efficient Composite Concepts with Non-Traditional Load-Paths
AF02-250	Aerial Targets Modernization and Integration
AF02-251	Integration of Hypersonic Vehicle Inlets, Isolators and Exhaust Nozzles for Multiple Engine Flowpaths
AF02-253	Metal Deposition for Locally Tailored Properties
AF02-254	High-fidelity Tools for Three-dimensional Multi-physics Computation
AF02-255	Reactive Flow Control for Virtual Aerodynamic Shaping
AF02-256	Distributed, Embedded Sensing for Quasi-Static Shape Control of Wings
AF02-257	Biologically Inspired Autonomous Control Technologies
AF02-259 (R&D)	Affordability Development and Integration into Simulation-Based Research and Development

OKLAHOMA CITY ALC, TINKER AFB

AF02-263	e-Learning and Aptitude Evaluation Through A Web-based Training Framework
AF02-264	Simulation of Repair and Rebuild Processes

Ogden ALC, Hill AFB

AF02-265 Aircraft Wiring Characterization, Tracking, and Testing System (AWCTTS)
AF02-266 Active Bus Analysis and Failure Forecasting
AF02-267 Sound Technology For Test And Diagnosis
AF02-268 Advanced Composite Materials Replacement on Metal Structures/Shelters
AF02-269 Performance Based Support Model
AF02-270 Advanced Molecular Coating Process
AF02-272 Semi-automatic or automatic development of Test Program Sets (TPS) without a board model using hardware reconstruct

WARNER ROBINS ALC, ROBINS AFB

AF02-276 Compact Hydrogen Storage using Metal Hydride
AF02-277 Micro JP8 Fuel Reformer
AF02-278 Advanced Electric Vehicle Research
AF02-279 72kw Hydrogen Fuel Genset
AF02-280 Aircraft Wiring Inspection System
AF02-281 Inspection of Subsurface Flaws Around Fasteners on Aircraft
AF02-282 Inspect Composite Components of the Aircraft

AIR ARMAMENT CENTER, EGLIN AFB

AF02-283 Sled Vehicle Aerodynamic Load Prediction Capability
AF02-284 Cellular Telemetry of Flight Test Data
AF02-286 Electromagnetic Modeling and Simulation (EMMS) Capability
AF02-287 Hybrid Computational Fluid Dynamics (CFD) Analysis System for Rapid Assessment of Store Separation
AF02-288 Global Positioning System (GPS) Simulator Phase Calibration
AF02-291 High Performance Real-Time Synchronization Clock

ARNOLD ENGINEERING DEVELOPMENT CENTER, ARNOLD AFB

AF02-292 Ultra High Speed Framing Pulsed X-ray System
AF02-293 Exhaust Gas Trace Species Detection System for Turbine Engines
AF02-294 Determination of Airframe and Weapons Bay Acoustic Signature in High Subsonic Speed Wind Tunnel Tests
AF02-295 Integrated Visible/IR Calibration Source
AF02-296 Non-Intrusive Flow Visualization Diagnostic System for Aircraft Flow Fields
AF02-297 Vortex Flow Detector for Turbine Engine Test Facilities
AF02-298 Microsensors for Gaseous Emissions Analysis

AIR FORCE FLIGHT TEST CENTER, EDWARDS AFB

AF02-301 Subminiature GPS Instrumentation (SGI)
AF02-302 Wireless Solutions for Time Space Position Information (TSPI) Data Links
AF02-303 Improved Aeronautical Global Positioning System (GPS) Antenna Systems
AF02-304 High Power, Miniature Infrared (IR) Sources
AF02-305 Clutter Model Based on Real-Time Terrain
AF02-306 Real-Time Infrared (IR) Source Calibration
AF02-307 Advanced Airspace Modeling, Characterization, and Planning

Air Force 02.1 SBIR Topic Descriptions

AF02-001 TITLE: Ultra-Wideband (UWB) Target Identification

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Based on advances in ultra-wideband technology, develop a capability to detect, identify, and locate ground targets.

DESCRIPTION: The wide bandwidth and short pulse length of ultra wideband (UWB) time domain impulse signals make it attractive for application to the detection, identification, and location of targets. UWB time domain signals are characterized by an impulse waveform with a rise time on the order of 100 to 300 picoseconds (ps) and a pulse width of 4 to 8 nanoseconds (ns). The concept of a time domain impulse application for target identification is not new, but new and innovative approaches are needed for time domain conformal receiver antenna concepts for small airborne platforms to make a system implementation feasible. The antenna requirements include the ability to provide a broad area of coverage for initial detection and focus on a specific potential target of interest. The antenna system should be capable of receiving analog time domain data signals with sufficient dynamic range to allow the target features to be extracted for target identification. The receiver components must also be capable of withstanding the high peak electromagnetic field levels that may be coupled to them during transmission of the main illuminating pulse. Both mono-static and bi-static configurations are of interest.

PHASE I: Develop a conceptual or preliminary design which would lead to the successful demonstration of the proposed innovative conformal receiver antenna system. Demonstrate basic antenna system concepts in a laboratory environment.

PHASE II: Develop and fabricate a prototype article, conduct laboratory, simulation and field tests which will demonstrate the capability that meets the requirements developed in Phase I. Create an application tree linking this proven technology to commercial and government uses.. Create an investment decision matrix of all the applicable uses as a function of need, utility, cost and schedule. The application tree and the investment decision matrix should only apply to uses that the prototype has successfully demonstrated during this phase. A more definitive requirements and validation specification shall be developed for the technology so that pre-production units in phase III can be built and tested in less time. Prepare a report containing the application tree and the investment decision matrix with the proposed selections for phase III. Develop commercial partnership interests for a Phase III production program.

PHASE III DUAL USE APPLICATIONS: The primary potential military application for this technology is the location and identification of obscured objects. Civilian applications include future time domain communications systems as well as airborne mapping of buried cables, pipelines, and mine shafts.

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2. C.E. Baum, E.J. Rothwell, K.M. Chen and D.P. Nyquist, "The Singularity Expansion Method and Its Application to Target Identification," Proceedings of the IEEE, October 1991.
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4. C.E. Baum, et al., "Polarimetric SAR Imaging of Buried Landmines," IEEE Trans on Geoscience and Remote Sensing, Vol. 37, No. 1, January 1999.
5. R. Kapoor, N. Nandhakumar, "Features for Detecting Obscure Objects in Ultra-Wideband (UWB) SAR Imagery Using a Phenomenological Approach", Pattern Recognition, Vol: 29, Issue: 11, pp1761-1774, November, 1996, Elsevier Science.

KEYWORDS: Targets, Ground, identification, Ultra-Wideband, Electromagnetic, Sensors, Airborne

AF02-002 TITLE: Optical Systems Fault Management

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop an optical systems fault management system for air- and space-borne optical applications.

DESCRIPTION: A dynamic optical diagnostics system is needed (including development of a data analysis tool) to create the capability for the Airborne Laser (ABL) to effectively detect and isolate faults and to provide diagnostics

data on demand to maintenance personnel for rapid correction of optical component failures. BACKGROUND: A frequent objective of optical systems diagnostics design is to provide feedback for initialization and monitoring of a system's performance and operational health. However, this approach does not correlate and store all pertinent diagnostic data in a nonvolatile memory that maintenance personnel can access on demand, nor does it expedite the unambiguous isolation of any system or weapon malfunction to the defective part or item. The information most important to the maintainer must be derived from the performance data. As more and more optical systems are developed and deployed, the need for maintenance-enhancing, integrated optical diagnostics systems grows. Such systems are needed to reduce operations and support costs and for developing refinements to existing systems. They may also play a significant role in developing specifications for the procurement of future systems.

PHASE I: Define the proposed system concept and specific system requirements. System requirements may include the ability to define decisions in need of diagnostic information, functions which need to be diagnosed, constraints on diagnostics and the ability to predict the performance of the proposed design. Demonstrate basic system concepts in a laboratory environment.

PHASE II: Provide a prototype component/system and laboratory demonstration which meets mutually agreed upon performance parameters and which demonstrates the capability to support both ground and airborne experiments in government laboratories or aircraft. The prime interests at this stage are deliverable system hardware and a clear demonstration of an integrated high-performance system capable of a 20-year lifetime.

PHASE III DUAL USE APPLICATIONS: Tremendous growth in the use of adaptive optics -- especially in the field of astronomy -- along with the requirements of Airborne Laser (ABL), Space Based Laser (SBL) and Ground Based Laser (GBL), has created a market composed of commercial and Department of Defense (DOD) customers seeking effective optical fault management systems. Successful development of the described system could lead to further interest and opportunities for related applications in both the defense and commercial sectors. The transition from defense to commercial applications may be expected to follow a pattern comparable to the introduction of adaptive optics.

REFERENCES:

1. Baird and Hanes, in Kinglake, Applied Optics and Optical Engineering, vol 4, New York, Academic, 1967.
2. Habell and Cox, Engineering Optics, London, Hilger 1948. Hopkins, in Shannon and Wyant, Applied Optics and Optical Engineering, vol 8, New York, Academic, 1980.
3. Strong, Procedures in Applied Optics, New York, Dekker, 1989. 4. Yoder, Opto-Mechanical System Design, Dekker, 1986. G. Smith, J.B. Schroeder, S.Navarro, Haldeman, "Development of an Integrated Diagnostic Strategy to Support Autonomic Logistics," Proc. of Air Force Logistics Symposium, March 1997.
5. R. Cowan, W. Winer, "Integrated Diagnostics", February 1997, DTIC ADA324130, Georgia Institute of Technology, Atlanta, GA, Office of Naval Research/XB Contract #N00014-95-1-0539.
6. Mil-STD-1814 "Integrated Diagnostics" 30 April 1991 pg 150-162.

KEYWORDS: Optical systems, optics maintenance, diagnostics, fault detection, fault management, fault isolation, optical path difference, photometric terms, aberrations, diffraction, data analysis tools, Airborne Laser (ABL), Space Based Laser (SBL), Ground Based Laser (GBL).

AF02-003 TITLE: Drilling 170 Micron Diameter Holes

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop a high-speed drilling process to be less labor and time intensive. The rapid drilling process must maintain hole quality and be non-invasive to thin metal plates.

DESCRIPTION: The ABL laser system uses a Singlet Oxygen Generator [SOG] to produce excited oxygen for its lasing process. Inside the SOG is an injector head that has to produce very fine droplets of Basic Hydrogen Peroxide [BHP]. The PDRR ABL has six laser modules, and each laser module has 20ea injector heads. Each injector head has 12,288 holes drilled, that are appx 170 micron in circumference. These holes are to be drilled into thin metal plates (~0.2 to 5.0 mm in thickness)which are made of metal alloys (see notes below). There are 6 modules for PDRR [1,474,560 holes] and 14 modules for EMD [3,440,640 holes]. For our Fully Operational system that consists of 7 A/C, it would require [24,084,480 holes]. Drilling this many very precise holes is very time consuming and labor intensive. The rapid drilling process must also be non-invasive to the thin metal plates.

PHASE I: Define the proposed system concept, specific system requirements, and predict the performance of the proposed design. Demonstrate basic system concepts in a laboratory environment.

PHASE II: Provide a prototype component or system and laboratory demonstration to mutually agreed performance parameters. Demonstration drilling process must be capable to support ground demonstration in a government facility and be qualifiable for an airborne experiment. The prime consideration must be deliverable system hardware and a clear demonstration of the integrated high-performance system.

PHASE III DUAL USE APPLICATIONS: There is tremendous growth in the use of COIL technology, especially in commercial drilling and cutting. With this increase along with requirements of ABL and GBL a requirement is created for an effective and efficient drilling system. It is expected such a system will find an abundance of applications in the commercial and defense sectors. Also, the rapid drilling process may have many other applications for hole drilling in materials.

REFERENCES:
1) "Specifications for Rapid Hole Drilling," by William P. Latham, Air Force Research Laboratory/Directed Energy Directorate, unpublished, copies of this document are available on request, contact Dr Latham, william.latham@kirtland.af.mil
2) "Short-pulse Laser Ablation of Solid Targets," C. Momma, B. N. Chichkov, S. Nolte, F. von Alvensleben, A. Tunnermann, and H. Wellig, Optical Communications Vol. 129, pp. 134-142, 1996.
3) "Microdrilling of Metals with Ultrashort Laser Pulses," H. K. Tonshoff, et. al., in the Proceedings of the Laser Materials Processing Conference, ICALEO '98, LIA Vol. 85, A-28 (1998).
4) "Laser Drilling of Small Holes," W. E. Maher, in the Proceedings of the Laser Materials Processing Conference, ICALEO '95, LIA Vol. 80, (1995).

KEYWORDS: Singlet Oxygen Generator, LASER, Basic Hydrogen Peroxide, Injector Head, Micro-hole Drilling, Lasing Process

AF02-004 TITLE: Beam Train Flexible Structure Control for Airborne/Space-Based Systems

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Incorporate information about the structural modes of airborne/space-based platforms into controller design to improve feedback loop performance of optical acquisition, tracking, and pointing (ATP) systems.

DESCRIPTION: For airborne/space-based platforms, a lighter weight structure can lower total mission cost and increase acceleration capabilities, and thus improve performance of related Acquisition, Tracking and Pointing (ATP) subsystems. The choice of a lighter weight structure, however, comes at the cost of more challenging structure control problems - especially in cases where tracking and re-targeting performance enhancements are pursued in optical assemblies. Passive damping methods or structural redesigns can sometimes mitigate this problem, but for high performance systems this is not possible. In some examples, the coupling of slew maneuvers and noise sources with the flexible modes of the system can cause modal excitation and movement of optical components that can dynamically impact wavefront error. Solutions exist such as low bandwidth control that are reliable and robust but have limited performance, while model-based control designs have robustness and implementation issues such as plant migration and modeling errors. However, the number of tools available for solving and analyzing this problem has grown. Faster processors, thin-film PZTs, residual mode filter model-based control methods, scanning laser vibrometers for multi-point sensing, and integrated optical/structural modeling tools such as IMOS are all new technologies that can help to realize a system more capable at dealing with this problem. Approaches are sought that combine hardware choices with advanced control algorithms & system ID tools that can be applied to slewing ATP systems with nontrivial dynamic responses to allow fast retargeting without structural dynamics/control interaction effecting wavefront error.

PHASE I: Phase I tasks should be focused toward identifying structure control issues for representative airborne/space-based optical systems. Specifically, model-based data should be used to characterize sensitivities to line-of-sight retargeting, misalignment and tracking, while investigations into control algorithm methodologies such as reduced order model based-methods should be included. Models should allow for the characterization of the disturbance environment, both acoustic and vibration. Potential hardware approaches to be used in Phase II such as thin-film PZTs, actuated optical mounts or other possibilities should also be investigated in the models for applicability and design sensitivities.

PHASE II: Phase II tasks would be directed towards the evolution of the hardware/software solutions investigated in Phase I to a brassboard/breadboard test traceable to a large telescope systems such as ABL or SBL.for a flight demonstration on the ABL platform. The benefits of flexible structure control will be proven. . Finally, loop performance measures will be contrasted with those of conventional control approaches to assess the new technology.

PHASE III DUAL USE APPLICATIONS: Because most motion control problems have some flexible modes that impact controller design, this work can apply to a large number of problems. The step and settle problem is also ubiquitous in motion control problems. For pointing systems this can result in faster re-targeting times. Airborne and Space Based Laser will benefit from this tool along with other DoD systems employing a targeting system. Commercial applications of control with lightweight structure include large crane and small assembly gantries and astronomical telescopes. These applications involve minimizing structural mass (to maximize acceleration and minimize thermal time constants) while maintaining precision position control.

REFERENCES:

1. Mathur, M.S., et al., "Characterization of Containment and Limiter Materials," SPIE, v3413, 1998, pp.192-1982.
2. Wood, Gary L., et al., "Material Requirements for Optical Limiting," SPIE, v1692, 1992, pp.2-143.
3. Watkins, S.E., et al., "Mapping of Absorption in Optical Coatings," SPIE, v1624, 1992, pp.246-255

KEYWORDS: precision pointing, structural mode control, controller design, vibration suppression/compensation, high energy laser pointing, Adaptive Control, Flexible Structure Control

AF02-005 TITLE: Frequency-Agile Monolithic Micro-Laser with Ultra-Narrow Linewidth

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a compact, monolithic, ultra-narrow linewidth, frequency-agile, frequency-programmable, solid-state laser.

DESCRIPTION: Narrow linewidth, frequency-agile lasers have been of significant interest because of their wide applicability in different areas, including spectroscopy, frequency conversion, etc. It is a key supporting technology for a low cost laser tracking system to support ground, air or space based launch vehicle and satellite control operation. A variety of methods have been proposed and demonstrated for achieving tunable single-mode operation, including the use of non-planar ring oscillators, birefringent tuning filters, twisted-mode resonators, and microchip laser designs. Although all of these methods show promise in some areas, they all have some limitations in frequency tunability, scalability, ruggedness and/or ease-of-use. In particular, the tracking of fast moving objects require a wide tuning range and better single frequency control than can be achieved with existing single-frequency tunable lasers. Moreover, many on-board systems include the laser as a subsystem component and need an inexpensive micro-laser module in compact monolithic configuration. The goal of this program is to develop a monolithic micro-laser with a free-running frequency stability better than 1 kHz/s for both jitter and thermal drift, and a fast-controllable tunability in the range of 30 GHz/ms. A number of applications require an ultra-narrow linewidth with an adjustable frequency, fast frequency tuning of the laser system will be incorporated for locking onto an external reference.

PHASE I: Develop an innovative new concept for a compact, ultra-narrow linewidth, diffraction limited, rapidly tunable (greater than 30 GHz/ms over 30GHz), single-frequency laser with output power up to 1 W. The frequency output of the laser must be programmable. The development should place emphasis on frequency stability (< 1kHz/s jitter and drift), fast tunability, and monolithic configuration. At the end of Phase I, the feasibility of proposed design must be demonstrated, and a breadboard system must be built and tested for compliance with the requirements. The design must show clear superiority to state-of-the-art products currently available.

PHASE II: Fabricate the prototype laser unit designed in Phase I with the proven concept transitioned into a robust , compact, and monolithic package. Test the laser and compare the results to the performance objectives. Demonstrate fast and controllable frequency tuning, power stability, diffraction limited output, etc. Determine limiting parameters of its operation and characterize its performance sensitivity.

PHASE III DUAL USE APPLICATIONS: Numerous applications require or benefit from the use of scalable, frequency-stable, fast-tunable laser sources in a compact monolithic package. . Private sector applications include wavelength division multiplexing, spectroscopy, and high-density optical data storage. Military applications include remote sensing, range finding, target designation and illumination, satellite tracking, and satellite communication. The most expensive component of all these instruments is the laser. Currently available solid-state modules are difficult and expensive to maintain, mainly because of difficulties with keeping the alignment in the field. The laser module consists of many optical components each mounted separately in the resonator. Because of the complexity of its design, the laser cannot be re-aligned in the field and has to be sent back to the workshop or replaced. This is very costly and unrealistic. Development of the compact laser module with monolithic configuration will reduce costs and increase reliability. Such an approach leads to reduction of the number of components, mitigates laser complexity, and simplifies fabrication.

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1. T.J. Kane and R.L. Byer, "Monolithic, unidirectional single-mode Nd:YAG ring laser," Optics Letters, vol. 10, no. 2, p. 65 (1985).
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4. J.J. Zayhowski and A. Mooradian, "Single-frequency microchip Nd lasers," Optics Letters, vol. 14, no. 1, p. 24 (1989).
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KEYWORDS: Monolithic laser cavity, Frequency-agile laser, Ultra-narrow linewidth, Wide tunable range, Fast-controllable tunability, Frequency stability.

AF02-006 TITLE: Solid State Low Energy Lasers for Space Based Lasers

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop efficient space qualifiable solid state lasers for Space Based Laser systems at 2.7 microns.

DESCRIPTION: The Air Force Space Based Laser Directorate (SMC/TL) and the Research Laboratory's Directed Energy Directorate (AFRL/DE) are seeking new, innovative technology developments in solid state lasers in the average power range of 1-10 watts. These lasers can be continuous (preferred) or repetitively pulsed with a satisfactory pulse schedule. Technology must result in electrically efficient systems with excellent beam quality and with the potential for traceability to cost effective, compact, reliable, space qualifiable systems. The Space Based Laser used for the Integrated Flight Experiment (IFX) requires a Low Energy Laser (LEL) system to serve as a high fidelity surrogate for the High Energy Chemical Laser (HEL) during startup and optical alignment portions of test operations. As a surrogate, the beam characteristics and dimensions of a LEL developed laser device must be able to match those of the HEL beam. The LEL is intended to provide an end-to-end beam to align laser resonator optics, to align precisely the Laser Payload Element with Beam Control and Beam Director Elements, to allow testing and functional verification of beam diagnostics, and to allow low power testing and demonstrations of mission utility. The LEL operates at specified positions in the 2.6-2.9 microns wavelength regime or at the third harmonic of this regime. To date, no known laser systems approach 10 watt average power in either wavelength regime. In the infrared, one option may be scaling a diode pumped solid state laser such as a rare-earth ion-doped garnet or Nd:YAG, pumping a periodically poled lithium niobate crystal to operate as a optical parametric oscillator (OPO). An intracavity OPO scheme has reached 1 watt (Ref.1). At 0.9 microns, a Nd-based MOPA (master oscillator power amplifier) laser system might be considered (Ref.2). This laser device, at elevated peak and average powers, will enable diagnostics development for, as examples, chemical flows (Ref.3) and remote sensing applications.

PHASE I: Develop design of proposed solid state laser device, using appropriate design tools, past experience, and analyses to justify design. Propose approaches, possibly a demonstration or a brassboard to demonstrate the device feasibility and assess performance potential. Begin risk reduction tasks to support design.

PHASE II: Complete design and build prototype solid state laser. Demonstrate the laser and perform (contractor/Air Force mutually agreed) testing, with diagnostics, to assess laser power characteristics, beam characteristics, electrical efficiency, thermal management, and turn-on time behavior.

PHASE III DUAL USE APPLICATIONS: A successful laser is readily applicable to the Space Based Laser Beam Control Testbed and later Integrated Test Unit program. As a laser source at new wavelengths and power levels, the laser is readily integrated into applications for remote sensing, illumination and ranging, environmental pollution and contaminant monitoring, the development of combustion devices, such as jet, automotive, and rocket engines, non-equilibrium chemical and plasma flow research, and chemical lasers.

REFERENCES:
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2. Comaskey, B. et al. "A one kilowatt average power diode pumped Nd:YAG folded zigzag slab laser" Proceedings of the SPIE - Diode Pumping of Average-Power Solid State Lasers,1865, 9-16, 1993.

3. P.B. Keating, C.A. Helms, B.T. Anderson, T. L. Rittenhouse, K.A. Truesdell, and G. D. Hager, Proceedings of the 19th International Conference on Lasers, 1997, pp 194-201, (1997).

KEYWORDS: Lasers, Solid state lasers, Optical parametric oscillators, Space Based Lasers, Directed energy weapons, Optics, Optical alignment techniques remote sensing, Lidar applications, Environmental monitoring, Chemical flow diagnostics

AF02-007 TITLE: High Energy Laser Diagnostics for Space Based Applications

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop space qualifiable diagnostics for high-energy laser diagnostics

DESCRIPTION: The operation of a high energy laser in space as part of the Integrated Flight Experiment (IFX program) will require measurement of the various parameters characterizing the high energy, HF laser beam (2.6 to 3.1 microns) at various points. To make these measurements, a number of diagnostic instruments will be required. The present state of the art instruments for High Energy Laser (HEL) diagnostics are heavy, usually cooled, voluminous, manually aligned instruments with small dynamic range; in short, unsuitable as is for incorporation into an autonomous flight system design. The goal of this effort is to develop HEL beam diagnostics that are traceable to primary and secondary National standards. All diagnostics would be expected to be self aligning, capable of internal calibration, require no external cooling, and eventually space qualifiable. Diagnostics of this type, along with expected basic performance requirements, would include (but not limited to): spectrometers, with energy resolutions of at least 800, wavelength calibration of better than 1%; calorimeters, with uncertainty in total energy of less than 8%; power meters, with uncertainty in power of less than 8%; polarimeters, to determine the polarization state to less than 2% (equivalent error in Stokes parameters); wavefront sensors, capable of measurements of less than l/50; and tilt sensors, with resolution of sub-microradians. Also of interest are devices that can measure the properties of the HEL resonator optics, reflection, transmission, scatter, absorption, particulate contamination and ellpsometric properties in situ.

PHASE I: Design and prepare supporting traceability analyses for suitable diagnostic devices. The traceability analyses must be consistent with NIST (National Institute of Standards and Technology) and ISO (International Standard Organization) publications on the calculation of uncertainty.

PHASE II: Develop a prototype instrument or brassboard version of the device. Evaluate the prototype against the traceability analysis and compare to existing traceable instruments to verify its performance.

PHASE III DUAL USE APPLICATIONS: Diagnostics of this type will be insertable into all present and planned HEL programs, ABL (Air Borne Laser), THEL (Tactical High Energy Laser) and follow ons, SBL (Space Based Laser). Commercial uses include monitoring of industrial high energy (power) systems such as laser welders, drills and cutters.

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1. R. F. Tate, B. S. Hunt, C. A. Helms, K. A. Truesdell, and G. D. Hager, "Spatial gain measurements in a chemical oxygen iodine laser (COIL)," IEEE Journal of Quantum Electronics, Vol. 31 No. 9, pp. 1632 - 1636, (September 1995).
2. J. M. Herbelin, T. L. Henshaw, B. D. Rafferty, B. T. Andeson, R. F. Tate, T. J. Madden, G. C. Manke II, and G. D. Hager," "The measurement of gain on the 1.315 micron transition of atomic iodine in a subsonic flow of chemically generated NCl(a1D)," Chem. Phys. Lett., Vol. 299, pp. 583 588, (1999).
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4. B. E. A. Saleh and M. C. Teich, Fundamentals of Photonics. (John Wiley & Sons, Inc., New York, 1991).

KEYWORDS: Spectrometers, high-speed laser power measurements, intensity profilers, polarimeters, calorimeters, wavefront sensors, centration sensors, tilt sensors, beam size determination.

AF02-008 TITLE: Active In-Situ Contamination Control

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop on-orbit cleaning technology for optical components used on satellites.

DESCRIPTION: The SBL Program Office and Air Force Research Laboratory (AFRL/DE) are interested in the development and eventual space qualification of technologies for cleaning optical components that are exposed to the high laser intensities within the Integrated Flight Experiment (IFX) and operational SBL systems. When a High-Energy

Laser (HEL) beam is introduced into space-based beam control and beam director subsystems, as will be the case for SBL, the need for active contamination control is evident. Laser irradiated particles on component surfaces can be heated to high temperatures, causing local damage to high-reflectivity, anti-reflection and dichroic thin-film coatings. Damage sites may later propagate across these surface coatings under subsequent HEL loading. Black body emission from the laser-irradiated incandescent particles may also optically saturate pixels within IR and visible cameras that are required to acquire and track targets. In addition to periodic on-orbit cleaning, an initial cleaning of critical optical surfaces may be required as a result of the release of large numbers of particles within the payload, following satellite launch. Unfortunately, no technique for removing particles from critical optical components has been validated on orbit. Prior work on ground systems indicates that two-phase CO2 jet-spray techniques outperform most conventional cleaning systems, removing sub-micron and micron-size particles from fragile surfaces, including many hydrocarbon films. The objective of the present SBIR task consists of two parts: 1) design, integration and qualification of cleaning system hardware that could be flown in a space demonstration that would support the IFX and operational SBL systems and 2) a laboratory demonstration of cleaning of actual SBL coatings (components to be provided by the Air Force) including measurement of contamination levels (pre- and post-cleaning) on the SBL-specific geometry coated components

PHASE I: Develop/design/construct a functional breadboard cleaning system. Prepare sample candidate SBL coatings, demonstrate cleaning of the coated (contaminated) surfaces, and determine resulting surface scatter by means of Bidirectional-Reflectance Distribution-Function (BRDF) measurements for the contaminated and actively cleaned surfaces. Quantify the possible build-up of electrostatic charge and subsequent development of discharge currents, and verify cleaning without microscopic damage to any of the multi-layer dielectric coatings tested. Products required at the end of Phase I (in addition to Final Report) is Phase II outline.

PHASE II: Finalize design, build, and test the cleaning system (selected as a result of Phase I activity) in a configuration suitable for space qualification. Verify cleaning of contaminated coated components, without surface damage or electrostatic breakdown. Utilize cleaning system to assist with space qualification of the active-cleaning ground hardware and software. Demonstrate component cleaning, without coating damage, and quantify the extent to which particles and surface contaminants are removed.

PHASE III DUAL USE APPLICATIONS: Assuming space qualification, the cleaning system would have wide application for future commercial/DoD satellites requiring on-orbit cleaning.

REFERENCES:
1. J. L. Clark, Mark Culpepper and Erwin Myrick, "Carbon-Dioxide Jet-Spray Cleaning Technology and the ACES Experiment," AIAA/BMDO Technology Conference, Session 10, Paper No. 5, 17-20 July 2000, San Diego, CA
2. J. L. Clark, M. Culpepper and P. T. Chen, "New Contamination Engineering Technology for Active On-Orbit Surface Cleaning," SPIE Conference, Session 2, Paper No. 4096-11, 2-3 August, 2000, San Diego, CA
3. W. Brandt, W. Cron-Schmidt and R. V. Peterson, "The Pathfinder Experiment on Particles After Jet Spray," SPIE Paper, Vol. 1754, p 306-315, 23-24 July 1992
4. R. V. Peterson and C. W. Bowers, "Contamination Removal by Carbon-Dioxide Jet Spray," SPIE Paper, Vol. 1329, p 72-85, 10-12 July 1990

KEYWORDS: Active surface cleaning, Momentum impact cleaning, Two-phase jet flows, Scatterometer measurement of particulate contamination, Removal of hydrocarbon thin films, Dielectric coating damage, Electro-static charging and breakdown, Particle contamination generator, Shuttle Space Test Program (STF)

AF02-009 TITLE: High Temporal and Spatial Resolution Laser Beam Diagnostic Sensor

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Remote sensor development for measurement of high energy laser beam profile at a target.

DESCRIPTION: High power lasers are currently in development that are designed to engage ballistic missiles during their active boost phase. These weapon systems are designed to engage the pressurized propellant tank or motorcase of the missile, causing it to fail in a catastrophic manner. During the test phase of the Airborne Laser system, the aircraft will be propagating a High Energy Laser (HEL) through the atmosphere onto dozens of target missiles; however, only a limited number of engagements versus operationally realistic targets will occur. In order to extrapolate the results of these tests to the full spectrum of targets, a detailed understanding of the beam characteristics at the target is required. Instrumentation capable of capturing the parameters required is not currently available. The required characteristics include: 1) the HEL spot location of the target, 2) the dwell time of the HEL beam on target, and 3) the temporal and spatial characteristics of the laser beam profile at the target. The development of a calibrated sensor which can measure

the beam profile at the target plane with a sampling rate of ~10-30 Hz and spatial resolution of ~1cm-4cm would significantly enhance the planned tests. Due to the anticipated safety keep out zones for the laser operation and the missile flyout, the sensor might need to be capable of being mounted on an aircraft or UAV that is many kilometers from the target

PHASE I: Initial research should determine the required performance of the instrumentation, identify potential solutions, and propose an optimal solution. The emphasis should be on off-board approaches that minimize the changes to target systems and comply with range safety considerations. The effort at a minimum shall address the target and engagement geometry; laser spot characteristics; sensor spatial, radiometric, and temporal resolution vs. laser spot characteristics; and calibration through the atmosphere. Hardware and software requirements should be determined.

PHASE II: Design, develop, calibrate, and demonstrate prototype sensor system. In addition, the system performance should be validated through realistic testing and demonstration.

PHASE III DUAL USE APPLICATIONS: The anticipated military application of the developed sensor technologies is future technology insertion into the Space-Based Laser (SBL) and Ground Based Laser tech (GBL Tech) programs. The potential commercial market includes industrial laser welding and cutting as well as long range thermal imaging.

REFERENCES:
1. J. Beraun, et al., " Airborne Laser Lethality Test Series, Volume I of II Subscale and Half Scale Targets," PL-TR-96-1051, Vol. I, Phillips Laboratory, KAFB, NM, June 1996. (Unclassified).

KEYWORDS: Laser Sensor, Directed Energy Weapons, Lasers, Ballistic Missile Lethality, Laser Reflectance, Laser Beam Diagnostics, and Infrared Radiometry

AF02-010 TITLE: High Temperature Target Failure Sensor

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Development of an onboard target failure sensor for High Energy Laser engagement with ballistic missile.

DESCRIPTION: Target vehicle response to laser weapon interaction is a critical parameter that needs to be well characterized. In a ballistic missile target that is being irradiated by a high energy laser (HEL), several parameters are of considerable interest. First, the temperature distribution on the wall is needed to determine the local strength distribution of the heated metal. Secondly, the fracture pattern is of interest to both verify catastrophic failure and validate modeling predictions1. While cost-effective failure indication sensors have been developed for hit-to-kill systems2, no such sensor exists for laser weapons. To this end a cost-effective solution to the development of a sensor array to measure the thermal distribution as well as fracture pattern on the tank wall. The sensor should be able to handle temperature >1000C. If externally mounted the sensor needs to have minimal interference with the incident laser beam and if internally mounted the sensor should be compatible with the fuel or oxidizer environment. A response time of the order of 100-200 msec is acceptable for the thermal portion of the sensor; however, the fracture pattern component data rates of up to 10 kHz will be required due to the rapid nature of the crack propagation1. Desired spatial resolution is in the range of 1 to 5 cm.

PHASE I: Efforts should focus in the area of research consisting of innovative concepts and establish measures of merit for selecting the best value concept. In addition, hardware and software requirements should be determined. Key features that need to be addressed are the harsh environment (thermal, mechanical, and possibly chemical) the sensor will be exposed to.

PHASE II: Design, develop and demonstrate prototype sensor system(s). In addition, the system performance should be validated through realistic testing and demonstration

PHASE III DUAL USE APPLICATIONS: The anticipated military application of the developed sensor technologies is future technology insertion into the SBL and GBL tech programs. The commercial market includes the industries involving high temperature environments, such as space reentry vehicles and high power engines in addition to reactor vessels in chemical processing.

REFERENCES:
1. Beraun, et al., " Airborne Laser Lethality Test Series, Volume I of II Subscale and Half Scale Targets," PL-TR-96-1051, Vol. I, Phillips Laboratory, KAFB, NM, June 1996. (Unclassified)

2. "Navy Proves Kinetic Warhead Capability for Theater Defense," Missile Defense, 9 Aug 1999.

KEYWORDS: High Temperature Sensor, Directed Energy Weapons, Lasers, Fracture Mechanics, Ballistic Missile Lethality, Thermal Profiling

AF02-011 TITLE: New Thermal Sensors for Use with Inverse Heat Conduction Problems

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop thermal sensor that can measure directly the rate of change of temperature with time and/or the rate of change of heat flux with time.

DESCRIPTION: The Air Force Research Laboratory Directed Energy Directorate is interested in investigating advanced concepts to develop novel sensors that can directly measure the rate of change of temperature with time and/or the rate of change of heat flux with time. This rate of change measurement is particularly important for determining thermal response and properties at the inaccessible or hostile locations such as the surface of a structure exposed to a directed energy beam, a wall exposed to fire or explosion, the outer surface of a reentry vehicle, or the surface of a combustion chamber.Because inverse problems of heat conduction are ill-posed, their solutions do not satisfy the general requirements of existence, uniqueness and stability under small changes to the input data. Thus the solutions obtained for inverse heat conduction problems can be extremely sensitive to the type of data acquired and to noise and lack of resolution in those data1. Typically, in addressing such problems, temperature or heat flux2 are measured at other locations in the body of interest and various analytical techniques are used to attempt to infer the information desired. It has been suggested recently that temperature is not the best type of data to use for solving many inverse heat conduction problems. Therefore, novel concepts and techniques are needed to address the inverse heat conduction problems.

PHASE I: Investigate and demonstrate the concepts and techniques for resolving the ill-posed heat conduction problems and designing thermal sensors for such purposes. The sensor(s) should be compatible with both metal (steel and aluminum) and composite structures, be able to handle temperature approaching melt of the structure, and heating rates from 50 to 1000 W/cm2.

PHASE II: Develop, fabricate and demonstrate prototype thermal sensors. The proposed demonstrations should verify the performance of these sensors on a class of inverse heat conduction problems for both metal and composite structures.

PHASE III DUAL USE APPLICATIONS: The anticipated military application of the developed technologies for inverse heat conduction problems and thermal sensors is future technology insertion into the SBL and GBL tech programs. The commercial market includes the industries involving high temperature environments, such as space reentry vehicles and high power engines. In addition, any application where the heated surface can not be directly measured yet conditions of that surface need to be determined would benefit from such a device.

REFERENCES:
1.R. Keltner, B. L. Bainbridge, and J. V. Beck, "Transient Temperature Measurement Errors," ASME paper 83-HT-86, 1983.
2. J. M. Hager, L. W. Langley, S. Onishi, and T. Diller, "Microsensors for High Heat Flux Measurements," J. Thermophysics and Heat Transfer, Vol. 7, No. 3, p.531, 1993.
3. J. I. Frankel, "Inverse Heat Conduction and Data Type Issues for Advanced Diagnostic Analysis," J. of Shanghai Jiaotong University, Vol. E5, No. 1, p. 321, 2000.

KEYWORDS: Thermal sensors, Inverse heat conduction problems, Thermophysical property, Directed energy beam, Heat flux, Transient thermal response

AF02-012 TITLE: Active Target Tracking through Deep Atmospheric Turbulence

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Conceptualize, simulate and demonstrate an active tracking system capable of improving active tracking performance in deep turbulence at high bandwidth.

DESCRIPTION: The Air Force is interested in active tracking in deep atmospheric turbulence - Rytov parameters greater than 0.75. Such turbulence causes a track image to be highly scintillated and distorted, when viewed at the tracker focal plane. Typically, isoplanatic angles are smaller than the diffraction-limited angle and the track requirements are less than the isoplanatic angle. Conventional and time-tested tracking paradigms do not provide maximum tracking accuracy for these cases. We seek an investigation of algorithms, together with a hardware implementation, that makes optimal use of a-priori information, such as knowledge of target shape, noise statistics, and information from other sensors, such as higher order aberrations, etc. We believe that improved tracking accuracy may require use of information that is not found in the last frame of tracker data - information such as past data, knowledge of atmospheric and scintillation statistics, and information from other sensors. Our thoughts for other sensors specifically include wavefront sensor information. However we do not rule out other approaches which may add sensors, such as a pupil plane imager, or which combine the adaptive optics and the track problem. In addition, we have recently been impressed by imagery from the medical imaging community in which difficult target information has been extracted in very tough environments.

PHASE I: Develop and investigate active track algorithms that promise improvement in tracking capabilities over the usual algorithms such as centroid, correlation, etc. Simulation and analysis will be performed to determine viable candidates for implementation. Select one or more candidates for implementation in Phase II.

PHASE II: Perform final high-resolution simulation of tracker algorithms developed in Phase I and down select to an algorithm(s) that promises considerable tracking enhancement in the deep turbulence regime. Develop and test a prototype tracker implementing such algorithms.

PHASE III DUAL USE APPLICATIONS: A tracker which is capable of performing accurate track in deep turbulence will have wide application in the DOD community, where long-range tracking through extended atmospheric paths is required. A primary application is for the Airborne Laser System. However, the technology will benefit any laser projection or imaging system that has stringent track requirements and must also operate in deep turbulence. Such systems include THELF, ATF, and SBL when operating in a look down mode. Other applications areas include airborne imaging and shipboard tracking of long-range targets through extended atmospheres. Strictly commercial applications include tracking for imaging systems for TV news helicopters and helicopter imaging systems for power-line-insulator damage detection.

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1.Andrews, L. C. and Phillips, R. L., Laser Beam Propagation through Random Media, SPIE Optical Engineering Press, Bellingham, 1998.

2.Brown, W.P., "Simulation of Laser Propagation on Long Stratospheric Paths", Proceedings of SPIE, Aerosense, 3065, Orlando, FL, 23-25 April, 1997.

3.Merritt, P., Cusumano, S., Kramer, M., O'Keefe, S., & Higgs, C., "Active Tracking of a Ballistic Missile in Boost Phase", Proceedings of SPIE, Acquisition, Tracking and Pointing, 2739, 1996.

4.Roggemann, M. C., and Welsh, B, Imaging through Turbulence, CRC Press, New York, 1996.5.Steiner, T., Butts, R., "Airborne Laser Advance Technology Testbed (ABLE ACT)", Proceedings of SPIE, Aerosense, Airborne Laser Advanced Technology, Orlando Fl, 13-17 April, 1998.

KEYWORDS: Tracking, High Scintillation, Sensor Fusion, Track Algorithms, Lasers, Atmospheric Compensation, Adaptive Optics

AF02-013 TITLE: Develop Coatings that Repel Contamination

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop coatings for high-energy laser mirrors and windows that repel contamination while not affecting the transmission of the high-energy laser beam.

DESCRIPTION: Research and develop a coating process that can maintain strict cleanliness requirements for use with high power lasers and optical systems. The applied coating should repel contaminants such as water and various kinds

of particulate matter. The coating must be Very Low Absorbtion (VLA) with regard to laser beams in visible and near infrared regions of the spectrum. The coating must be very thin to prevent aberrations in the beam path. The film or coating must be reliable and durable enough to withstand the high-energy laser energy that will pass across the coating/film. Processes and equipment to inspect and maintain optical elements must support, and in fact provide for cleanliness factors. This includes changes in temperature, humidity, and pressure experienced by the system.

PHASE I: Define the proposed coating concept, specify system requirements, and predict the performance of the proposed design. Demonstrate basic system concepts in a laboratory environment.

PHASE II: Provide a prototype coating process for high-energy laser mirrors and windows that repels contamination with a laboratory demonstration that meets mutually agreed upon performance parameters. Demonstration processes and coating must be capable of supporting ground demonstration in a government facility and be qualifiable for an airborne experiment. The prime consideration must be a deliverable coating process and a clear demonstration of the integrated high-performance system with an expected lifetime no shorter than the optical surface to which the coating is applied.

PHASE III DUAL USE APPLICATIONS: The technology could be used in Airborne Laser (ABL), Ground Based Laser (GBL), Space Based Laser (SBL), Space Based Infrared System (SBIRS), and NASA SOPHIA programs. Examples of commercial applications include optical systems (telescopes, for instance) or window coatings for commercial (and other) buildings.

REFERENCES:
1. Kevin F. Fitzgerald, et al., "Mass Modeling for Electrically Powered Space-Based Yb:YAG Lasers," Gas, Chemical and Electrical Lasers and Intense Beam Control and Applications, Santanu Basu, Steven J. Davis, Earnest A. Dorko, (eds.), Proceedings of SPIE Vol 3931 (2000).
2. W. S. Watt, "Solid-State Laser Technology: Status Report Dr. Dwight Dustin, BMDO," July 29, 1997.

KEYWORDS: Ultraviolet irradiation , hydrophobic surface, oleophilic coating, optical systems, optical coatings, optical materials, optics maintenance, high energy lasers, contamination control.

AF02-015 TITLE: All-Optical High-Energy-Laser Beam Control

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop/demonstrate passive phase-conjugation for end-to-end correction of HEL phase aberrations/jitter.

DESCRIPTION: The recently completed AF/BMDO HEL Affordability and Architecture Study mandated by USD (A&T) concluded that high-bandwidth, high-control- authority HEL beam-control systems provide an important means for reducing the cost of future space-based HEL systems for use in national and theater missile defense. The Study found that a 10-fold improvement in beam-control performance would enable short-wavelength HELs and large-aperture SBLs, potentially reducing the cost of SBL systems from over \$100B to under \$70B. Similar cost savings may be possible for other HEL systems, such as Airborne Laser and Ground-Based Laser systems. Both the SBL Program Office (SMC/TL) and Air Force Research Laboratory (AFRL/DE) are interested in development of passive nonlinear phase conjugation (NPC) technologies or alternate technologies for end-to-end clean up of optical beams produced by high-power multi-line chemical and solid-state lasers. For example, NPC technologies possess far greater bandwidth and control authority than adaptive optics technologies that are used in current HEL beam control systems. Novel and innovative NPC concepts that are based on four-wave mixing and/or stimulated scattering (SBS or STS) are of special interest. In general, these methods will use a double-pass oscillator-amplifier geometry in which a master oscillator (or illuminator target return) injects a backward-directed reference wave of high optical quality into the beam director, beam control, preamplifier, and amplifier laser elements. The reference wave is modulated by all of the optical-train and laser-induced wave-front errors and jitter sources. The backward wave is "phase conjugated" at the focus of a nonlinear medium by formation of an optical grating, where the beam is reflected and its wave front is reversed. The reflected beam, in turn, retraces precisely the incident path, systematically unraveling the wave-front errors and jitter that were imposed on the beam during the backward pass. Technical challenges for tailoring the NPC or alternte process to multi-line chemical laser systems include master oscillator isolation, high conjugation fidelity/reflectivity, out-coupling the forward-directed high-power amplifier beam, and pointing the HEL beam at a thrusting target with proper lead ahead. In principle, the NPC process can perform wave-front error/jitter corrections with temporal and spatial frequencies that represent orders of magnitude improvement over conventional adaptive-optical (AO) systems. In addition, weight and cost savings associated with the relaxation of requirements for vibration isolation, active optical- figure control, and control of laser-medium inhomogeneities should be significant. In addition to the

requirement for simplicity and high performance relative to conventional AO techniques, the proposed concept must be lightweight, efficient, compact and space qualifiable. For the NPC example, prior work has emphasized beam clean up of solid-state pulsed laser sources (Ref. 1). A program to demonstrate beam clean up of a continuous-wave chemical laser beam is in progress at TRW using an SBS process (Ref. 2). A Russian group has recently demonstrated a single-line approach for end-to-end clean up of a laser system consisting of a laser payload element and beam director element (Ref. 3).

PHASE I: Develop a detailed design of the NPC demonstration or alternate concept that will be performed during the Phase II effort. Include model descriptions, simulation results, supporting data (when available), and other technical analyses that justify the hardware design and its ability to control chemical-laser wave-front error and beam jitter. Where necessary, risk reduction activities should be conducted to support critical aspects of the proposed design. Products that are required at the conclusion of Phase I should be a critical design review, Phase II proposal, and final Phase I report. This effort will require innovative R&D not just design work.

PHASE II: Fabricate, integrate and assemble the NPC or alternate approach test bed and diagnostic apparatus. The use of long-pulse chemical-laser amplifiers, preamplifiers, and master oscillator to simulate a high-power continuous-wave chemical laser is acceptable for the Phase II demonstration. Characterize the ability of the NPC or alternate concept to correct phase errors and jitter at the spatial and temporal frequencies associated with high-power chemical laser systems. Conjugation thresholds, reflectivity, and conjugation fidelity of the clean-up process should be measured, experimental data should be compared with theory, and any performance limitations associated with the clean-up process should be established. A method for including the beam director in the conjugation process should be demonstrated that includes acquiring and tracking a thrusting target at long range, accounting for the effects of target lead ahead.

PHASE III DUAL USE APPLICATIONS: The NPC concept or alternate process demonstrated herein would readily support applications that do not involve high-power lasers. These applications include imaging through aberrated media (for example, the atmosphere), precision auto-tracking of satellites and other targets, and imaging through opaque media (clouds, water). Other important applications include high-bandwidth laser communications with satellites, high-resolution imaging through large optical telescopes, and acquisition and tracking in general of targets with lead ahead (for example, by means of adjusting the angle of the four-wave mixing "pump wave").

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3. L. S. Vasilenko, et al., Pis'ma Zh. Eksp. Teor. Fiz. Vol. 12, 1997.

KEYWORDS: Passive phase conjugation, Nonlinear optics, Laser beam clean up, Four wave mixing, Stimulated Brillouin scattering, Phase compensation, Jitter compensation, Image compensation, Lead ahead compensation, Remote imaging

AF02-017 TITLE: Coatings for Large, Lightweight, Compliant, and Scalable Deployable Space Optics

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop a method to use stress coatings to shape compliant optics into a parabolic net-shape, with the ability to measure various characteristics of the coating.

DESCRIPTION: AFRL is interested in technologies that will lead to large space-based optical telescopes. There has always been a need for coating optical surfaces to protect the surface or what resides behind the surface. In the past, dielectric coatings were applied to thin glass surfaces to improve the reflectivity. Unfortunately, in many cases the glass or coating would deform, crack, or delaminate after many layers of coatings were applied. Yet, the coating was still not thick enough. The source of the glass breaking is due to stresses (compressive or tensile) created during the coating process. Many years were spent trying to eliminate or reduce the stress induced by these coatings. However, the Membrane Mirror Team has discovered these coatings could be used for shaping flexible, compliant materials into a net-shape, specifically concave.· The shaping of flexible, compliant materials or membranes could revolutionize the future of space optics. Through the use of shaping membranes with a stress coating, a much larger satellite, with the capability to be "folded and deployed", can be designed for many space applications. The end purpose would be to create larger telescopes in the 30-50 m class. · The requirement calls for developing a stress coating method to shape an optical quality compliant material, currently available on the commercial market. A parabolic net-shape is

desired since the main purpose is for space telescope applications. Currently, a stress coating is applied to the surface to maintain the shape of the cast membrane. · Since membrane manufacturing is relatively undeveloped, the surface quality contains hills and valleys, which reduces the optical characteristics and abilities of the membrane. A possible method to correct for these aberrations is to apply a coating to essentially fill in the valleys, so the whole surface has little local tilt error. The method described would greatly increase an already high-quality membrane in production today. · For both methods, material and mechanical properties of the coating or other process would need to be researched, including, but not limited to, uniformity, thermal management of the application and laser effect to surface. · Without a uniform coating, the stress induced could cause warping in the surface; therefore, producing membranes with an unacceptable shape and low optical quality. Different material types should be researched to resolve which one will have the best across-the-board characteristics. A few materials should be used during the testing process to prove through experiments, which will actually meet the requirements. · In reference to other optical characteristics, different properties deemed important should be researched and if necessary, tested. Some of these include, but not limited to, the lifetime of the coating in different environments, the resistance to cracking or peeling during different conditions and its reaction with the membrane material. The percent stress induced by the coating is highly critical, because the coating stress has to balance with the membrane to hold its parabolic shape. The membrane and coating combination must be able to be folded and "spring" back to its original shape without appreciable memory shape loss.This SBIR is searching for fundamental technologies that will supply structural support to a compliant material by an optical coating.

PHASE I: The contractor shall model their selected approach to show the shape control of the coating. This modeling should include the details of the mechanics and at some level the expected non-uniformities caused by the coating and its processing. Coupon or small scale material testing will be used to establish or validate the appropriateness of the model. Scalability and applicability of the concept to the space environment must be addressed.

PHASE II: The contractor shall use the results of Phase I to build, test, and refine a 1-meter test article.

PHASE III DUAL USE APPLICATIONS: These coatings have many general uses, including, but not limited to the following: Creating lightweight communication satellites and inexpensive methods to shape compliant structures for optical systems.

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KEYWORDS: Membrane Optics, Optical Quality Reflectors, Space Capable, Thin Films, Reflectors, Large Aperture, Solar Collectors, Thin Film Structures, Compliant Structures.

AF02-018 TITLE: Application of Quantum Cascade Lasers to High Explosive Detection

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Fabricate a frequency agile or broad frequency laser source array detection device in order to detect effluents emitted from high explosive (HE) compounds commonly used by terrorists.

DESCRIPTION: The growing threat of terrorist attack in both military and civil environments and the ready availability of compounds to produce high explosive devices indicate a need for suitable high explosive detection devices. Preliminary inquiries to DOE, Army, FAA, and industry have highlighted a gap in our knowledge of what kinds of compounds are emitted by the candidate high explosives. The U.S. Air Force, U.S. Navy, Defense Threat Reduction Agency (DTRA) and Federal Aviation Administration (FAA) have placed high priority on the ability to

sense high explosive compound effluents from standoff distances to determine safety for our personnel against terrorist strikes. The required detection capability would come in the form of a fixed site, ground based unit capable of monitoring areas surrounding deployed forces as well as docked naval assets. Remote sensing technologies suitable for counter-drug, counter-terrorism or counter-proliferation applications could provide early warning of a threat in ample time to evacuate a facility, relocate an asset, or disable the device prior to its implementation. Detection ranges from 30m up to 1km are required to satisfy user requirements. Desired technologies include (1.) Amplification of laser power in order to detect effluents from high explosive compounds. Possible methodologies are packaging of Quantum Cascade (QC) lasers into arrays or fiber coupling medium and short wave laser sources. Techniques for amplifying laser output to higher powers while maintaining good beam quality and wavelength stability are also of interest. Emphasis will be placed on system size and weight, cost, reliability, and maintainability. (2.) Ability to achieve advanced wavelength stabilization for improved detection as well as significantly higher unit output power without monumental impact to system size.

PHASE I: Define the proposed concept and develop key component technological milestones and preliminary design of system or components that address one or more of the above desired capabilities. The system approach is desired in order to ensure that the components developed have utility in meeting the requirements defined above and can be suitably field-tested with existing government furnished equipment or hardware (GFE) in Phase II.

PHASE II: Complete component design, fabrication and laboratory characterization experiments. Define field test objectives and conduct limited testing with available GFE, if needed.

PHASE III DUAL USE APPLICATIONS: With the added ability to detect high explosive compound effluents, this lidar system could be used by both military and private sectors for troop insertion area monitoring as well as counter-terrorism purposes, without modification.

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KEYWORDS: high explosives, high explosive detection, chemical sensing, stand-off detection, fiber coupling, differential absorption lidar (DIAL)

AF02-019 TITLE: Real Time Adaptive Signal Processors for On-line Performance Optimization of Adaptive Optical Systems

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Demonstrate real time adaptive signal processor that can implement an adaptive reconstructor for an adaptive optical system.

DESCRIPTION: The Air Force is interested in the propagation of laser beams from airborne platforms over long atmospheric paths. We are specifically interested in the Airborne Laser (ABL) system, but note that innovation for this system will also apply to GBL, relay mirror, airborne imaging, low elevation SBL and remote sensing. These systems require operation in engagement geometries with high relative wind velocities (due to relative motion of the aircraft and target, or due to satellite slew) and other forms of anisoplanatism. In environments such as these, the servo lag and data latency become critical design drivers, often severely limiting the performance of the system. Adaptive / predictive estimation schemes that compensate for data latency have shown potential to provide significant performance improvements in such conditions (Ref 1, 2). The difficulty with adaptive estimation schemes is the complexity of the processing, typically requiring on-line modification of the matrices used to compute deformable mirror commands from multiple sensor measurements. The goal of this effort is to produce a scalable software and hardware architecture for implementation of adaptive signal processors for on-line optimization of adaptive optical systems. While simulations of adaptive optical systems using an adaptive filter have used the lattice filter described in Reference 3, it may be that other forms of RLS filtering - fast QR methods or Givens rotations - may prove more amenable to hardware implementation. The hardware and software architecture should be flexible enough for other applications requiring high-speed, high-dimensional adaptive filtering.

PHASE I: Create a software architecture and hardware design to implement a fast (> 1 kHz.), high-dimensional (200 by 200) adaptive filter to perform tasks such as described in References 1 and 2. Since these criteria are difficult to meet, the contractor is expected to provide an innovative solution that matches the chosen filter architecture to advance hardware concepts. The contractor will also provide a plan for a feasibility demonstration of the approach and outline a sound set of demonstration success criteria. A design review will cover the hardware and software architecture and planned evaluation of the feasibility demonstration.

PHASE II: Fabricate and demonstrate the adaptive processing architecture developed in Phase I and show that it leads to improved Strehl in imaging or laser projection systems. The offeror may test the concept at his/her facility, or, at the offeror's request, the AFRL may arrange to conduct the test at the ABL Advanced Concepts Laboratory operated by MIT Lincoln Laboratory or at the Air Force Research Laboratory's Airborne Laser Advanced Concepts Testbed located at the White Sands Missile Range North Oscura Peak Facility. These facilities will be provided to the contractor at no cost to the contractor or the SBIR Program. It is expected that this phase will provide a new wavefront reconstruction capability that is sufficiently validated to readily facilitate transition to systems such as the Airborne Laser.

PHASE III DUAL USE APPLICATIONS: It is expected that an adaptive optics subsystem based on the concepts proposed under this research, with economical considerations folded in, would have both commercial and military applications. The military applications include all those with requirements for precise atmospheric compensation through turbulent media. These applications include ABL, Relay Mirror, remote sensing, and atmospheric imaging programs. The commercial market includes such areas as astronomy, communication, power beaming, and surveying. Clearly a hardware architecture that optimally implements a high-bandwidth, high-dimensional lattice filter would have numerous applications outside of the adaptive optics community. These applications include: Image tracking and prediction; active vibration and noise control; adaptive channel identification, deconvolution, and equalization in various radar systems. It is expected that the contractor will concentrate on flexible Phase I designs to maximize commercialization potential.

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KEYWORDS: adaptive optics, wavefront reconstruction, adaptive control, beam control

AF02-020 TITLE: Tracking Through Laser-Induced Clutter for Air to Ground Directed Energy Systems

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop HEL tracking algorithms to deal with background clutter. The effort should include target and aimpoint identification, and tracking.

DESCRIPTION: Future combat airborne directed energy programs have a need to actively track slow moving ground targets in a changing scene environment. Target recognition algorithms have shown promise in some conditions at picking out objects during acquisition, but scene variations due to laser effects make the problem significantly more difficult. Laser induced scene problems such as operating under different weather conditions, smoke conditions, under camouflage conditions, during thermal blooming or with background reflections can make acquisition and aimpoint selection difficult over the duration of the engagement. Other fire-control issues such as anisoplanatism of the track point to the aimpoint also reduce the overall effectiveness of these systems. This effort looks at proposing new innovative methods to address these problems and ultimately build a set of tools to solve the downlooking ground target acquisition, engagement tracking, and aimpoint problem as it relates to background clutter.

PHASE I: Identify new and innovative techniques and methods for addressing the overall problem of acquisition, tracking, and pointing a combat laser beam in an air-to-ground scenario under different ground clutter conditions. This will include during different weather conditions (clouds, fog, etc.), smoke conditions, camouflage conditions,

vegetative covers, etc. The effects of anisoplanatism and thermal blooming must also be addressed. Initial screening of existing algorithms is desired. After identifying the new concepts, the effort should create a validation plan that leads from computer simulations , to laboratory experiments, to field validations. AFRL will potential scenarios that require engaging targets against background clutter prior to Phase I kickoff for the contractor to use. For each scenario, a preliminary evaluation will be performed to determine if passive or active sensing for tracking best meets the requirements for that mission. Innovative methods using radar, pulsed vs. continuous wave lasers, selection of frequencies, etc. should be considered for the different parts of the problem. Algorithms and tests using a sensor developed in the DARPA Three Dimensional Imaging Sensors program or similar sensor developed by MIT/LL could be a valuable enhancement to the effort, but is not required.

PHASE II: During Phase II continue development of the algorithms such that implementation issues and any minor technical issues are addressed. Testing of the algorithms in a realistic, non simulation environment, such as the AFRL-funded Advanced Compensation Lab or other facility will also be performed. Tests will be conducted according to the plan developed in Phase I. Preliminary demonstration of algorithms at the AFRL North Oscuro Peak (NOP) facility or other non-brassboard site will also be conducted. If needed, use of the NOP test facility will be provided at no cost to the contract or to the SBIR Program.

PHASE III DUAL USE APPLICATIONS: Tracking or observing objects through smoke and fire conditions has been always been a problem for firefighters as well as vehicles attempting to navigate through fog. Infrared scanners are often deployed on large forest fires, but only provide pertinent information on the actual fire line underneath the smoke. The acquisition portion of this project could lead to a considerable increase in information from the overflights-such as location of equipment and personnel. Infrared-based look ahead systems are already available on some cars but imaging through clutter is still a problem that could be expanded under this effort.

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KEYWORDS: Tracking, High Scintillation, Clutter, Track Algorithms, Lasers

AF02-021 TITLE: Periodically Poled Stoichiometric Lithium Tantalate for Nonlinear Optical Frequency Conversion

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop a process to produce large-size optical-quality stoichiometric lithium tantalate crystals for nonlinear frequency conversion.

DESCRIPTION: Frequency-agile laser sources have important military applications, including infrared counter-measures, remote sensing of environmental chemicals, lidar, and guide-star generation for adaptive optics. While recently developed periodically poled ferroelectric crystals such as periodically poled lithium niobate (PPLN) and periodically poled KTP isomorphs (PPKTP) have greatly enhanced the possibilities for nonlinear frequency conversion, these materials are not well-suited for some applications. Recently a process was developed by which large-size (45 mm diameter, 50-85 mm length) nearly stoichiometric single-crystal boules of lithium tantalate could be grown. This growth was accomplished using a double-crucible Czochralski method which did not cause damage to the crucibles when the melt solidified. Periodically poled stoichiometric lithium tantalate (PPSLT) has optical and poling properties far superior to the usual congruently grown material. This PPSLT was used to make an optical parametric oscillator. PPSLT (unlike PPLN) is transparent to the third harmonic of the Nd:YAG laser. It may be possible to pole stoichiometric lithium tantalate samples as thick as 5 mm (1 mm is the maximum commercially available thickness for PPLN). Because dn/dT in PPCLT is less than 5% of the value in PPLN, thermal lensing and disruption of phase matching in PPCLT at high average power should be much less severe than in PPLN. This SBIR topic is aimed at fostering the development of a commercial source of PPSLT.

PHASE I: Design, build, and test apparatus for growth of large-size, high-purity, nearly stoichiometric lithium tantalate. Perform preliminary evaluation of crystals (size, purity, absorption spectra, resistance to photorefractive damage, economics of large-scale production).

PHASE II: Carry out periodic poling of stoichiometric lithium tantalate with various grating periods and wafer thicknesses. Make accurate measurements of the extraordinary refractive index, which may differ significantly from that of congruent lithium tantalate. Make improvements to the crystal growth process to optimize crystal properties for applications from the infrared to ultraviolet. Make PPSLT crystals suitable for Air Force frequency-conversion applications.

PHASE III DUAL USE APPLICATIONS: Because of its ultraviolet transparency, PPSLT has potential applications to photolithography and laser medicine. It may be possible to use dual-grating PPSLT together with resonant enhancement to efficiently generate the important third harmonic of the CW Nd:YAG laser. Optical parametric oscillation using PPSLT could be used to produce multiple wavelengths in the infrared or visible for military applications and for color projection. Infrared parametric oscillation, pumped by Nd:YAG lasers or Yb fiber lasers, could be used to generate tunable eye-safe wavelengths for remote sensing and lidar. PPSLT offers the potential for good performance at high average power for frequency conversion of both CW and pulsed sources if long, large-aperture, high-quality crystals can be produced economically.

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KEYWORDS: stoichiometric lithium tantalate, stoichiometric LiTaO3

AF02-022 TITLE: Artificial Dielectrics for High Power Microwave Applications

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop lightweight artificial dielectrics for High Power Microwave (HPM) source lens designs.

DESCRIPTION: This effort will develop lightweight artificial lens materials that can be used to design and fabricate high power microwave lenses for use in either narrow band or ultra wideband (UWB) microwave antenna applications. Current lenses utilize polyethylene for the lens material with a resulting severe weight penalty. An artificial dielectric material that can be used for these lenses is desired. One possible approach is based on approaches utilized for microwave communications applications. A similar approach may be feasible for wideband time domain applications. The current microwave lens approach incorporates small dielectric spheres with a conductive coating suspended in a lightweight holding material. For UWB applications the artificial dielectric material should be effectively dispersion less and loss-less over a frequency from 200 megahertz to 2.0 gigahertz. Whether this concept can be extended for UWB applications is not clear. However, other new and innovative solutions that will produce a lightweight lens material that is dispersion less over this bandwidth are needed and encouraged.

PHASE I: Investigate the concept of using different dielectric spheres or spheres and/or tubes filled with fluids suspended in some type of lightweight foam or similar material to create an artificial dielectric material. Determine the feasibility of the concept and define the possible dielectric materials and the potential range of artificial dielectric characteristics possible with this type of an approach. Estimate the physical and electromagnetic properties of such artificial dielectrics for use in lenses and provide a sample product with actual measured results. Develop an initial commercialization concept and plan.

PHASE II: Complete the research initiated in Phase I and develop prototype artificial dielectric materials. Design and demonstrate a prototype system for limited production of such dielectrics and demonstrate the feasibility of the process. Conduct experiments and measurements of the physical and electromagnetic properties of the artificial dielectric materials. Develop business and commercialization plan for a Phase III engineering development and marketing

program. This plan shall be required to address the real world issues associated based on actual business planning procedures, sources and methods of securing venture capital for production engineering and marketing, and not just a superficial discussion of possible approaches and possible customers.

PHASE III DUAL USE APPLICATIONS: Military uses of this technology include dielectric lenses for HPM narrow band and UWB antenna systems and communication systems. The civilian sector has similar requirements in the field of communication systems and especially in the newly emerging time pulse position technology for cellular phone and other similar applications.

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KEYWORDS: Dielectrics, Artificial, Antenna Lenses, Microwave, High Fields, Light Weight

AF02-023 TITLE: Grating Surface Emitting Semiconductor Laser Incoherent Array with High Average Power

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a high-average-power semiconductor laser source with increased brightness. This will increase the optical intensity that can be coupled into solid-state lasers and the power that can be coupled into fiber lasers.

DESCRIPTION: Any method, that will result in the development and commercialization of semiconductor laser sources with power levels of several hundred watts and with increased brightness over sources that are currently available, is sought. One method for accomplishing this would be to make an array from grating surface emitting (GSE) lasers. GSE lasers can be made to be very long with an output power per unit length that is comparable with that of typical edge emitting lasers. This provides the potential for a one-dimensional array of emitters that is comparable in power with an array made of stacked bars. If beam-shaping techniques were applied, the brightness would be much higher due to the fact that the array would be one dimensional. The array could consist of narrow-stripe individual lasers or of wide-stripe lasers. Even with lasers that were far from being diffraction limited in the lateral dimension, such an array could be much brighter than a conventional array of stacked bars. Innovative research would be required to develop chips that: (1) minimize loss of light caused by bi-directional emission; (2) include efficient heat transfer from the active region to the heatsink; (3) allow uniform current injection and low resistance. Another method for accomplishing the objective would be to make an array from stacked bars of edge emitting lasers, with individual lasers having improved beam quality or increased output power. Innovative research would be required to develop lasers with good beam quality at high power and with stable modes.

PHASE I: Design, model, and perform adequate proof-of-principle demonstrations for the individual lasers or subsystems to give confidence for the success of a Phase II program.

PHASE II: Based on Phase I designs, models, and proof-of-principle demonstrations, conduct in-depth development and refinement of laser source. Fabricate prototypes to show a maturity of technology toward potential commercial and military applications. Deliver prototypes to the Air Force.

PHASE III DUAL USE APPLICATIONS: Military applications for high-power high brightness laser sources such as those resulting from this proposal are principally weapons-related. Examples of commercial applications for a high-brightness, high-power source include: pumps for fiber lasers; laser cutting, machining, and welding of plastics or thin metals; materials processing; medical applications and any other area where a compact, efficient and mechanically robust source of intense infrared radiation is required.

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KEYWORDS: diode laser, semiconductor laser, array, grating

AF02-025 TITLE: Novel Low-Noise Extra High Frequency Amplifiers

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop the technology and infrastructure for manufacturing micro-vacuum tube low-noise amplifiers for space applications.

DESCRIPTION: Improvements in sensitivity of RF receivers in satellite systems offer a number of benefits, i.e. relaxation of size and weight demands on the receiving antennas and enhancement of the overall system reliability. Reducing the noise floor in the first amplifier stage is generally regarded as a highly effective means of increasing RF receiver sensitivity. This topic seeks innovative ideas of reducing amplifier noise through the use of a Micro-Vacuum Tube (MVT) as the low-noise front end of the first stage. Recent developments indicate that micro-triodes fabricated from chemical vapor deposited diamond micro-tip cold cathode emitters and self-aligned grids offer, in addition to low noise, high input impedance, high gain, and extremely high operational frequency. The thermal noise generated in these devices should be much less than traditional vacuum tubes since cold cathode electron emission occurs at room temperature or below if required. Unlike semiconductor low-noise amplifiers, MVTs have vanishingly small grid capacitance and extremely high input impedance, making them ideal for very high frequency (>30 GHz) and low-noise pre-amp applications. The goal is to develop a novel low-noise amplifier technology for applications in space systems. The initial phase of this effort calls for the development of prototypes to demonstrate the benefits of low-noise MVT amplifiers for K-band and above. The goal is to develop low-noise amplifiers that will be significantly better than the current state-of-the-art counterparts.

PHASE I: Demonstrate the merits of MVTs as used in low noise amplifier applications. Measurements on noise, gain and bandwidth will be made and compared with the current state-of-the-art counterparts. Address radiation hardness issues (total ionizing dose, dose rate, single event phenomena). Demonstration of the feasibility of developing an integrated multi-stage amplifier with a low- noise MVT front end is crucial for Phase II funding.

PHASE II: Design and fabricate an integrated multi-stage low-noise amplifier circuit with an MVT first stage. The emphasis of the Phase II effort is on verifying the performance of the developed integrated amplifier circuits based on actual measurements of gain, bandwidth and noise floor. An additional Phase II product is the definition of the infrastructure required for the production of MVT low-noise amplifier circuits. The circuit must meet adequate radiation tolerance requirements for usage in space by major USAF programs.

PHASE III DUAL USE APPLICATIONS: Low-noise, high gain and wide bandwidth RF amplifiers should have numerous applications in the commercial communication markets, (both space-based and terrestrial) such as cellular telephony, mobile data linkage and space/ground satellite communication. The knowledge and experience gained in Phase I and II will be used to develop products for both commercial and military applications.

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KEYWORDS: Low-noise amplifiers, LNA, Micro-vacuum tubes, Diamond micro-tips Micro-triodes, Cold cathode emitters

AF02-026 TITLE: Dynamic DC Source and Load System with Energy Recycle Capability

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop electronic DC source/load system that significantly reduces cost of power conversion system testing.

DESCRIPTION: Conventional testing/validation costs of power conversion systems designed for high power applications dramatically adds to the overhead cost of product development. Because the test load consumes 100% of

the input energy, the heat generated from the testing increases the power consumption of the test facility. This further contributes to the overhead expenses of the whole organization. This is the motivation behind the concept of a "smart electronic load" (SEL) that absorbs the electrical energy delivered from the "system under test" (SUT) and passes the energy back to the DC power source providing the input voltage to the SUT. The SEL is simply a highly efficient DC-DC converter that can be programmed to have different characteristics, as needed, i.e., a resistive, a constant current-sink, or a constant power load. The DC power source (providing input voltage to the SUT) is a highly efficient AC-to-DC converter processing the AC utility power into a well-regulated output voltage with sufficient energy storage - such as a set of bulk filter capacitors terminated across the source output. This energy storage is capable of holding and filtering the energy transferred from the utility grids and the recycled energy from the SEL so that the power quality at the input of SUT remains acceptable especially during line and load transients. The AC-to-DC converter can also be designed to behave like a resistive load to the utility grid; thereby, yielding almost unity power factor and low harmonic contents in the line current.

PHASE I: (1) Determine technical feasibility of selected SEL testing approach (that yields high power factor and low harmonic contents). Identify a testing architecture best suited for medium and high power systems under test. (2) Determine SEL system design guidelines to achieve system stability/reliability. (3) Develop SEL design showing system interconnection of the AC-to-DC converter, the SUT, the electronic load, and their respective controllers. (4) Validate the design concepts through results from computer simulation and analyses of the system response.

PHASE II: (1) Finalize design of the power system/components: the AC-to-DC, the electronic load converter, and their controllers. (2) Simulate final design through the computer simulation/analysis. (3) Construct breadboard SEL system and demonstrate contractor/Air Force mutually agreed basic concepts

PHASE III DUAL USE APPLICATIONS: As the computer and communications industries continue to increase their markets there will be an increased need to better utilize electric power used in the production of these electronic products. At the same time the nation's electric utility supply grid is seeing an marked increase in the demand for electric power to operate the internet and in the manufacture of the electronic devices which make up this system. The ability to accurately measure the performance of each power processing component to verify that power processing parameters are within specified tolerances with a minimal use of electric power should provide a significant commercial market for this device.

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KEYWORDS: Dynamic DC Source, Load System, DC-DC Converter, Energy Recycle,Power Electronics Test Equipment, AC-to-DC converter

AF02-027 TITLE: Multifunction Phase Array Antennas

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop and demonstrate high efficiency, phased array antenna with integrated energy storage and enhanced array pointing precision.

DESCRIPTION: Current spaceborne communication and surveillance spacecraft employ sophisticated, single purpose phased array antennae for transmission (and/or reception) of RF energy. Integral to the performance of these devices are the separate power and thermal management subsystems, typically developed independently as part of the spacecraft bus. Precise pointing requirements for both communications and surveillance require precise knowledge and control of dimensional tolerances that are adversely affected by thermal distortions induced by waste heat from RF components. Because phased array antennas typically occupy large areas that tend to radiate heat rapidly in space, keeping transmit/receive modules warm enough is usually of more concern than keeping them cool. Power distribution for large phased array antennas may entail power transmission over relatively large distances that in turn lead to high power distribution losses and inefficient spacecraft operation. The combined effect of pointing requirements, thermal management and power distribution tend to increase the overall weight of the 'assembled' spacecraft. Significant reductions in spacecraft weight may be enabled by direct integration of power and thermal management functions at the component level of the phased array. The objective of this project is to develop technology that enables energy storage and thermal management at the components level of transmit/receive antenna modules. Potential system level benefits of this technology would be mass reduction and/or affordability improvement through higher level integration of payload with supporting technologies.

PHASE I: Develop and demonstrate innovative electronic packaging concepts to enable the integration of energy storage and thermal management is conventional phased array transmit/receive antenna subsystems that will provide significant overall spacecraft mass reduction. Invent, develop, and demonstrate of proof-of-principle breadboard designs that enable integration of energy storage and thermal management into transmit/receive antenna module (TRAM) devices. Conduct concept designs, thermal analysis and energy management/thermal vacuum experiments (if appropriate and as needed) to 1) demonstrate applicability of the multifunctional phased array antenna architecture to communications and surveillance systems of interest to the Air Force and DoD, 2) validate concept viability in representative operating environments through appropriate modeling and/or experiments, and 3) demonstrate system level benefit in terms of antenna mass/unit area of the proposed multifunctional phased array antenna.

PHASE II: Develop and demonstrate prototype RF transmit/receive phased array antenna incorporating integrated energy storage and thermal management modules. Validate RF performance using appropriate ground simulation and testing.

PHASE III DUAL USE APPLICATIONS: Application of this technology would permit next generation commercial satellite communication systems to display higher efficiency RF operation and higher transmitted output with existing energy generation technologies.

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2. Spacecraft Integrated Electronic Structures (SIES), Suraj Rawal, Lockheed-Martin, AFRL-VS-TR-1997-1011.

KEYWORDS: Phased Array Antennas, Multifunctional Structures, Energy Storage, Power Distribution, TRAM, Space-Based Radar (SBR)

AF02-028 TITLE: Next-Generation 35-40% Efficient Multijunction Solar Cell

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop/demonstrate single-crystal multijunction (3-4 junction) space solar cells with 35+% conversion efficiency..

DESCRIPTION: An increasingly higher level of electrical power is needed to run increasingly complicated and diversified satellites that are assigned longer and more complex missions. Next-generation large satellite demands include increased power on orbit, while increasing power system specific power (W/Kg) to increase satellite payload mass and power budgets. Satellite power generation is provided by solar photovoltaic cells (solar cells). Advanced 35-40% efficient multijunction solar cells promise to reduce SOTA solar array size and mass by 50-60% and enable significant power level scale-up from SOTA 15kW to ~25kW. The multijunction solar cells contain multiple layers of light sensitive semiconductor material that optimize solar energy-to-electrical power conversion. Each layer in the solar cell stack optimally absorbs and converts a different part of the solar spectrum into electricity. High performance solar cells are required to provide added power for space missions without increasing the solar arrays' size or weight. This program will investigate new semiconductor material systems and solar cell device designs capable of achieving 35-40% efficiency Air Mass Zero(AM0) to increase space solar cell efficiency by 50% (over recently developed AF ManTech 24% solar cells). The chosen material system must be current matched for two-terminal operation. While the preferred configuration is monolithic tandem, mechanical stacked approaches are also acceptable. Also, while a large area (>20cm2) 1-sun cell design is preferred, concentrator solar cell designs are of interest. Advanced 3- and 4-junction single-crystal multijunction solar cell designs will 1) Enable scale-up of military and commercial satellite power levels to >25kW from the current maximum practical power level of <15kW, 2) Significantly reduce solar array mass via increased solar cell efficiency; solar array size, mass, stowage volume and cost decrease with increasing cell efficiency, 3) Increase solar array power for constant solar array mass or size, and 4) Provide a high volume, cost-effective production capability for space solar cells two generations ahead of any production solar cells available abroad (UK,19-20%;Germany,20%, Japan, 17-20%)

PHASE I: Develop and validate innovative approaches for producing a 3- and/or 4-junction space solar cell design having theoretical efficiencies greater than 35% (AM0, space spectrum). Build on existing 26-28% efficiency multijunction solar cell designs and production capability. Solar cell modeling and design may be based on a wide range of semicondcutor bandgaps, including ~2.0, 1.4, 1.0, and 0.7 eV material combinations. Appropriate bandgap values must be selected to insure current matching. While lattice-matched material systems are desired, lattice-mismatched systems are may also yield good candidates.

PHASE II: Develop a prototype/demonstration of the high efficiency multijunction, single crystal solar cells. Develop/document requirements/plans for high volume production processes.

PHASE III DUAL USE APPLICATIONS: Dual use commercialization would occur through the development of cost-effective high-efficiency single-crystal solar cells which are of interest for both DOD and commercial spacecraft as well as for new terrestrial concentrator applications. The outlook for commercial space based arrays would be very strong.

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2. Lamorte,M. F., et. al., "Solar Cell Design Study", Research Triangle Inst, RTI-41U-1259, 1977

KEYWORDS: High-Efficiency Solar Cells, Multijunction Solar Cells, Space Power, Solar Arrays, Photon Absorption, Single-Crystal Solar Cell

AF02-029 TITLE: Phased Array Antenna Power Amplifier Modules

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop high efficiency solid-state power amplifier modules for application in multi-carrier components for spaceborne phased-array transmit antennas.

DESCRIPTION: This program addresses the need for simultaneous transmission of multiple carriers in RF power amplifier chains through the development and implementation of discrete power amplifier modules). Discrete power amplifier modules (PAM), suitable for being implanted in microwave integrated circuit (MIC) structures, will be used to demonstrate the desired performance enhancement. The power output of interest is between 0.1 and 1.0 watts with an input power of approximately ten milliwatts. Future applications will include military satellites such as Advanced EHF (extremely high frequency) and future surveillance systems such as Space-Based Radar, as well as commercial satellites operating in the 20 GHz transmit (downlink) band. Since multiple modulated carriers will be applied to the modules, the reduction of inter-modulation products is thought to be one of the key issues and should be considered. Potential voltage peaks that could cause device degradation as a consequence of beat frequencies should also be considered a one of the reliability issues. Compensation techniques may be required to meet performance goals. The compensation techniques to be considered include but are not limited to the following: 1) automatic gain and level control to maximize efficiency with minimum intermodulation products, 2) a predistortion network to improve linearity and phase matching, 3) wideband characteristics to enhance phase matching, and 4) temperature compensation circuits

PHASE I: Develop innovative approaches to enable high efficiency solid-state amplifier modules for future spaceborne phased-array transmit antennas. Demonstrate viability of developed approaches via modeling, simulation and/or brass-board experimental techniques. Conduct supporting system analysis to 'qualify' potential benefit to both military and commercial communication systems.

PHASE II: Validate proposed approaches via appropriate design, simulation and fabrication of prototype components to demonstrate performance capabilities of new approaches. Build the necessary PAM/MIC hardware and perform adequate demonstrations/testing to show that the contractor has achieved a significant improvement in amplifier performance with regard to efficiency, linearity, phase matching, temperature stability, and reliability through the use of compensating circuitry. Transition of program results to microwave monolithic integrated circuit (MMIC) technology in order to show compatibility with current module developments may be described and considered if appropriate within the scope of a phase II effort.

PHASE III DUAL USE APPLICATIONS: Phased arrays are receiving considerable attention in both the military and commercial space communications communities. The downlink transmit band at approximately 20 GHz is allocated to both types of service. Accordingly, the effort proposed is directly applicable to many systems under serious consideration for future deployment that involve multiple carrier transmission and in which the reduction of inter-modulation products is a key requirement.

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2. K. Yamauchi, K. Mori, M. Nakayama, Y. Mitsui, and T. Takagi, "A Microwave Miniaturized Linearizer Using A Parallel Diode," 1997 IEEE MTT-S Digest.

3. L. Rowe, C. Chen, M. Harley, J. Lester, S. Huynh, J. Chi, J. Choe, L. Ma, S. Pratoner, C. Wright, A. Ho, R. Lai, K. Brown, R. Duprey, W. Jones, and D. Chow, "Active Aperture Downlinks," Milcom 95 Conference Record.
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KEYWORDS: Solid-state Amplifiers, Linearizers, Phased Arrays, Antennas, Inter-modulation Products, Microwave Integrated Circuit, Space-Based Radar (SBR)

AF02-030 TITLE: Miniature Traveling Wave Tubes for Space Application

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop the technology and infrastructure for miniaturizing traveling wave tubes for space communication applications.

DESCRIPTION: Traveling wave tubes (TWTs) are commonly used to amplify microwave power for satellite communication systems. Fabrication of these tubes required intricate assembly practices and highly skilled manual labor. Progress toward higher frequency operation is hampered by the ability of present manufacturing technology to reduce the dimensions of critical components, such as helices and electron guns. An enabling technology is needed so that TWTs can be made to operate at higher frequencies. Advancement in this area will offer new mission capabilities and support the development micro- and nano-satellites. This topic solicits innovative ideas for miniaturizing TWT components by drawing upon the recent developments in microelectronics and micro-electro-mechanical systems (MEMS) technology. The goal is to develop a novel manufacturing technology to build TWTs to operate at frequencies at or above 100 GHz with a target output of 5 watts per subsystem.Incorporation of advanced MEMS fabrication techniques to the manufacturing process is encouraged. The initial phase of the program calls for the demonstration of concepts to be used to miniaturize critical TWT components. Concepts that can offer the potential of fabricating the entire system by MEMS technology are encouraged. Demonstrated ability to produce miniaturized prototype components is an essential Phase I product.

PHASE I: Establish an effective and viable miniaturization approach for TWTs and their components. Phase I objective is to establish a feasible approach required to demonstrate the feasibility of a TWT system which can meet Phase II requirements.

PHASE II: Design and build miniaturized TWTs to operate at frequencies at or above 100 GHz. The emphasis of Phase II is on verifying performance of miniaturized TWTs to demonstrate feasibility of producing 5 watts per subsystem at >/= 100 Ghz. In addition to developing the needed manufacturing technology, a critical part of the Phase II effort will be devoted to developing/documenting the infrastructure required to construct miniaturized TWTs in a Phase III activity.

PHASE III DUAL USE APPLICATIONS: Small, compact microwave power amplifiers, operating at high frequencies, offer enormous opportunities for creating new markets in the bandwidth-intensive commercial communication arenas, such as cellular telephony, wide band mobile communication and high-speed space/ground data transfer. The knowledge and experience gained in Phase I and II will be used to develop products for both commercial and military applications.

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2. O. Sauseng, A. E. Manoly and A. Hall, "Thermal Properties and Power Capability of Helix Structures for Millimeter Waves," Technical Digest, International Electron Devices Meeting, pp. 534-537.
3. T. J. Grant, R. Garcia and G. V. Miram, "Bonded grid electron gun for 95 GHz extended interaction amplifier," Technical Digest, 1983 International Electron Devices Meeting, pp. 141-143.

KEYWORDS: Travel wave tubes, TWT, Microwave tubes, Miniaturization, MEMS, Micro-electro-mechanical system, advanced RF packaging,

AF02-031 TITLE: Lightweight Primary Mirror Technology

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Design and develop high-stiffness, ultra-lightweight, scalable mirror fabrication/production techniques.

DESCRIPTION: Current light-weighting approaches to mirror fabrication using glass-based substrates are limited in achieving an optimal solution to both structural and optical requirements. Primary considerations in mirror design are optical performance (both static and dynamic), while secondary considerations include weight, minimum risk in fabrication, handling and polishing considerations, and the constraint that costs be kept at an absolute minimum. These secondary considerations have the effect of making mirror production rates exceedingly slow, with procurement times and costs that do not scale well with the mirror aperture. By fully utilizing new technologies, more structurally efficient mirror systems (i.e. less parasitic weight that serves no structural purpose) should be obtainable, while at the same time cutting cost, fabrication times, and reducing risks from handling.

PHASE I: Investigation of advanced, high payoff approaches to high-structural efficiency mirrors is desired. The advantages of the approaches investigated with regards to structural efficiency, optical quality, manufacturability, scalability, and environmental requirements should be demonstrated by analysis or historical data.

PHASE II: Finalize Phase I design and based on final design, develop a prototype component or system. Design and conduct laboratory demonstration based performance parameters derived from a military or militarily-relevant commercial application.

PHASE III DUAL USE APPLICATIONS: Due to the current high activity levels in both government and industry related to both the SBL and ABL programs, there are many opportunities for the advancement to a successful Phase-III program for this topic. Partnership with traditional DoD prime-contractors will be pursued towards this end. In addition, while government applications will receive the most direct and immediate benefit from a successful program, terrestrial optics also stands to benefit from the results of this program. In particular, high-structural efficiency steering mirrors could reduce complexity of any optical system with pointing requirements, including ground-based telescope applications, Printed Circuit Board photoetching systems, automatic identification systems, scanning and dimensioning systems, environmental & gaseous emission testing systems, Inspection mirrors, military & commercial aircraft mirrors, commercial and civilian remote sensing applications, and optical communications systems.

REFERENCES:
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KEYWORDS: Lightweight, Mirrors, Manufacturing, Structures, Optics

AF02-032 TITLE: Electrodynamics of the High-Latitude Ionosphere

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop an efficient, accurate software package that specifies and predicts the electrostatic potential, currents and Joule heating rates in the high-latitude ionosphere.

DESCRIPTION: The near-earth space environment has a direct and, sometimes deleterious effect on military operations. Systematic variations and perturbations in ionospheric density can adversely affect military and civilian communications, spacecraft charging, navigation systems, radar surveillance, and geolocation. Changes in the upper atmosphere modify the orbits of satellites and degrade our ability to predict their position and reentry. Between the altitudes of 80 and 1500 km, the upper atmosphere has two components: a neutral component -- the thermosphere -- and a charged component -- the ionosphere. Both form a strongly coupled system. At high latitudes, electric fields, currents and Joule heating rates constitute the key parameters of this coupled ionosphere-thermosphere environment. The objective of this SBIR is to devise innovative algorithms to characterize and predict these parameters. Being able to specify and forecast these electrodynamic parameters in near real time will significantly improve the accuracy of operational space weather models being developed for use by the Air Force and the Department of Commerce. Accuracy of tailored space weather products relies on validated and computationally efficient models for specifying

and forecasting the space weather environment. They are needed to identify and predict communication outages, navigational errors experienced by GPS single frequency receivers, surveillance radar malfunction, power grid disruption, and electric blackouts. The supplied electrodynamic software package will be a specification and forecast model that is driven by a mixture of data, theoretical modeling and climatology. It is intended to be used as an input to high-latitude ionospheric specification and forecast models, which are the basis for a number of application codes that generate parameters to support DoD and civilian missions.

PHASE I: Design a prototype software package that models the high latitude electric field, currents and Joule heating. This shall be accomplished in coordination with government personnel. Phase I activities shall include the following tasks: (1) Review relevant models of electric fields, ionospheric currents and Joule heating rates, as well as their limitations. (2) Design innovative concepts to specify the high latitude electrodynamic parameters. These concepts shall be based on state-of-the-art measurements, models, computer algorithms and assimilative techniques. (3) Based on these innovative concepts produce a workable design for an accurate and efficient software model of electric fields, currents, and Joule heating rates. (4) Formulate a thorough validation procedure including identification of necessary data sets, and definition of an appropriate set of metrics. (5) Write a Software Design document.

PHASE II: Develop an advanced specification and forecast software model of the high latitude electrodynamic parameters. This shall be accomplished in coordination with government personnel. Phase II activities shall include the following tasks: (1) Revise electrodynamic model Phase I concept. (2) Produce an accurate, efficient and validated high latitude electrodynamic specification and forecast algorithm. (3) Demonstrate its capability to enhance the performance of operational physics-based space weather models. (4) Demonstrate its capability to enhance the performance of tailored products that are based on the space-weather models. (5) Identify the required inputs -- such as data, physical models and empirical models -- that are required to generate the output. (6) Produce the Functional and the Software Requirements Documents.

PHASE III DUAL USE APPLICATIONS: Because this software package will be used as an input to space environment models, it has direct applicability to commercial vendors who develop tailored products for specific navigation and communication customers. Civilian users of single frequency GPS receivers require realistic ionospheric corrections to achieve accurate navigation position information. HF wave propagation prediction users are the largest customers for NOAA's Space Environment center forecast services, which requires realistic ionospheric models. Potential commercial uses include systems to assess the status of satellite communication channels, and electric power grid control centers to re-route circuit elements when major increases in the ionospheric electrojet are imminent. Thus, this software package is expected to have significant dual-use potential. Successful completion of this SBIR effort would favorably position the contractor to market a key component of a near real time space weather forecast model that would provide communication outage advisories, improved GPS navigation systems, and electric power grid decision aides. Other marketing opportunities and commercial uses will emerge from the algorithm's value and relevance to the US National Space Weather Program where the Nation's emerging space weather forecast capability is being coordinated and showcased.

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KEYWORDS: Space Weather, HF Communications, Electric fields, Magnetic fields, Joule heating, Ionospheric Scintillation

AF02-033 TITLE: Power Efficient Space Computer

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Design, fabricate and demonstrate a power efficient space computer

DESCRIPTION: Power consumption for mainstream microprocessors is increasing at an alarming rate. Semiconductor roadmaps predict that by 2005 microprocessors will operate at over 2GHz and may consume over 100 Watts – and in 2001 technology is almost there already. This suggests that space based high throughput processing will require active cooling in the near future. The associated penalties in reliability, complexity, and weight may be unacceptable for space use. For power-constrained use, including terrestrial battery-operated applications, new architectures and processes are being envisioned. This SBIR topic is intended to investigate techniques that go beyond conventional processor architectures, and discover new power-optimized architectures and processes for commercial and space use. Some possible approaches include simplified hardware using very long instruction words (VLIW), software-assisted hardware, and dynamic clock control. Reference 3 indicates some approaches used by the Caruso processor; no doubt there are other techniques that can be used when one breaks free of the traditional processor paradigms. Some of these techniques could also be appropriate for Application Specific Integrated Circuits (ASICs) as well as microprocessors. Other issues to be considered for space use include ionizing radiation and effects of single energetic particle strikes (Single Event Effects).

PHASE I: Provide evidence, through analysis and/or hardware demonstration, that key technology innovations can achieve improvements over current practices in power efficient design and architecture and can be used in relevant environments. Develop initial concepts and designs for products, whether microprocessors or ASICs, using the proposed technical innovations. Develop and describe a strategy to implement the innovations in a demonstration application. Identify key challenges to extending the innovations to space applications, including environmental effects, and propose solutions to overcome these challenges.

PHASE II: Implement and test Phase I innovations at a demonstration level. This demonstration need not be a full-scale or flight-level system, but should validate the key elements of the system.

PHASE III DUAL USE APPLICATIONS: Power efficient processing has broad applications for all battery-operated electronics. As energy use decreases, the single event effects concerns for space will increasingly apply to terrestrial electronics, particularly high altitude commercial avionics. This type of product would also be applicable to commercial space (as well as military space).

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KEYWORDS: Portable computing, microprocessor, low-power, VLSI, Central Processor Unit, space computer

AF02-034 TITLE: High Temperature Polymer Substrate for Thin Film Solar Cells

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop a High Temperature low density material suitable for use as a substrate for thin-film photovoltaic devices.

DESCRIPTION: Future space missions will require photovoltaic devices having specific power ratings in excess of 1000w/kg. Conventional crystalline photovoltaic technology cannot provide these specific power ratings due to the fact that the solar input is only 0.135 w/cm2 and the mass of crystalline devices is approximately 0.125g/cm2. Thus crystalline photovoltaic devices, even with 40% efficiency, have specific power ratings of approximately 400w/kg. Thin film devices, which have an area density equal to the substrate upon which they are deposited, have the potential of providing higher specific power ratings. Presently thin film photovoltaic devices are fabricated using vacuum deposition processes which grow the photovoltaic devices at relatively high temperatures (500 to 600oC). To accommodate the high temperatures required for high efficiency devices (greater than 10% AM0 [Air Mass of zero]) the underlying substrate which has proven to be workable is stainless steel. The use of stainless steel as a substrate for thin film photovoltaics has a number of drawbacks which adversely impact the overall specific power of a solar array. Two of these are: 1) the high density of stainless steel foils limits the maximum specific power rating and 2) the use of stainless steel precludes the implementation of an integrated interconnect system. Amorphous silicon photovoltaic

devices have been produced for the terrestrial market using a polyimide substrate, and an integrated interconnect system. This process is limited to a maximum temperature of 400 oC during the deposition process. The maximum efficiency that has been obtained for the production devices using this process is approximately 5% AM1.5. The specific power for these devices is approximately 300w/kg at AM0. To obtain a specific power rating of 1000w/kg an AM0 efficiency of approximately 15% is required. Significantly higher efficiencies could be obtained for thin film photovoltaic devices (fabricated on high temperature low density substrates) if the deposition process could be raised to 600 oC. Moderate improvements in cell efficiencies could be obtained with low density materials capable of surviving temperatures of 500oC. For phase I efforts, a strong emphasis should be placed on experimental and theoretical methods for validation of the design. Government/commercial test and evaluation facilities may be available; via documented requests (to appropriate organizations) to secure these facilities. Based on the results of these tests/evaluations, the performance of the thin film solar cells on low density material substrates should be estimated and improvements quantified.

PHASE I: Develop/validate innovative processes for producing space based, long life, high specific power (1000w/kg) thin film, solar cells fabricated at high temperatures (>500 oC) on low density substrates. Provide appropriate demonstrations of the products resulting from the selected processes

PHASE II: Develop/provide a laboratory based prototype demonstration of the solar cell array resulting from the finally selected production process.

PHASE III DUAL USE APPLICATIONS: Dual use commercialization would occur through the development of low cost high efficiency thin film solar cells which could be used for terrestrial/space applications. The market place for commercial space based/terrestrial solar arrays is strong and growing at a rapid rate.

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KEYWORDS: High Temperature Polymer, Thin Film Solar Cells, Specific Power, Solar Arrays, Polymer Substrate, Photovoltaic Devices

AF02-035 TITLE: Reconfigurable Logic for Space

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop/demonstrate innovative concepts for applying the advantages of reconfigurable logic to satellite electronics.

DESCRIPTION: With the advent of reconfigurable Field Programmable Gate Arrays (FPGAs) it is reasonable to conceive of insertions of this technology on board spacecraft where size and weight are almost always at a premium. The ability to dynamically reconfigure logic circuits allows the same component, an FPGA, to serve in several different functional capacities. While the potential for application of reconfigurable logic (circuits) is obvious, ways to leverage this potential are not fully explored. Many spacecraft on-board processing functions are fixed and in continuous use. These functions would not be good candidates for reconfigurable logic insertion. Good candidates include (among others) periodic/intermittent functions. Offerors should assume that space qualified reconfigurable FPGAs will be available when needed. Development of these components is not part of this topic. A proposal in this area should begin to address a number of problems not faced by conventional (non-dynamic) FPGA use. Such problems might include the design and testing of reconfigurable systems, the development of new architectures better suited to reconfigurable logic, and the issues of error detection and fault tolerance for reconfigurable systems.

PHASE I: Based on a proposed concept for an innovative set of generic applications of state-of-the-art reconfigurable logic to satellites, detail the functions and architectures necessary for actual implementations. Demonstrate (by analysis) size, weight, and (if applicable) power reductions achievable over standard (i.e., non-reconfigurable logic) approaches. Provide analytical demonstrations based upon at least two proposed reconfigurable logic concepts. For each such demonstration, compare similar analytical results produced from: 1) the "standard" approach implemented by state-of-the-art non-reconfigurable FPGAs, and 2) the "standard" approach implemented by state-of-the-art Application

Specific Integrated Circuits (ASICs) which are presumed to be of higher density than the FPGAs. Define in detail representative functions and implementing architectures to be designed and implemented in Phase II.

PHASE II: Implement a hardware demonstration of one or more of the most promising and innovative generic applications of reconfigurable logic (from Phase I) to satellite functions. While a demonstration of complete functions is preferred, demonstrations of complex functions can be partial if truly representative of the benefits of a full implementation. Implement the same functions in non-reconfigurable state-of-the-art FPGAs and demonstrate actual reductions in overall size/weight/power achieved (e.g., taking into account total chips required for the non-reconfigurable logic and for the reconfigurable logic approaches.

PHASE III DUAL USE APPLICATIONS: This technology is equally applicable to commercial satellite systems which face many or most of the same reliability, environmental, size/weight/power, and performance needs as military systems. As an enabling technology for integrated electronics, it has broad potential for significantly improving the performance and characteristics of most future military space systems, including MILSATCOM/SBIRS/GPS/etc. programs.

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KEYWORDS: Reconfigurable, logic, satellite, Field Programmable Gate Arrays, electronics

AF02-036 TITLE: Multi-functional Polymer Optical Interconnect Technologies for Wireless Satellite Data Communications

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop/validate designs for multi-functional polymer optical interconnect technologies for wireless satellite data communications.

DESCRIPTION: Integration of modern microelectronic devices (e. g., microprocessors, digital signal processors, field programmable gate arrays, etc) has increased to the point where external data transmission by electrical relay is constrained by the low number of possible input-output (I/O) channels that can be integrated on-chip. New schemes for I/O must be considered for such devices in order to avoid a more severe data extraction bottleneck on future devices that will be even more heavily integrated. In an effort to overcome these limitations, systems designers have been exploring the use of optical/optoelectronic interconnects. The integration of photonic devices (i. e., transmitters and receivers) on-chip allows data transmission chip-to-chip at rates exceeding 10 gigabits per second and avoids many of the bottlenecks associated with current system architectures. Data is transferred either through waveguides (e. g., optical fibers) or by free-space transmission. Use of optical/optoelectronic interconnection schemes in conjunction with microelectronic devices will require the development of polymer waveguide structures suitable for integration on-chip. Application/integration of optical/optoelectronic interconnects to applications of greatest utility to USAF satellite programs including MILSATCOM, SBIRS, etc., are of high interest.

PHASE I: Develop and validate innovative schemes for the use of on-chip polymer waveguide optical/optoelectronic interconnects in conjunction with microelectronic devices for military applications. Proposals should focus on the development of on-chip optical approaches (e.g., polymer waveguides and structures) to enhance fanout and/or facilitate dynamically-reconfigurable architectures for chip-to-chip, board-to-board, and system-to-system communications. These efforts should include proof-of-principle validation of the survivability and performance of optical/optoelectronic interconnects for systems consistent with the use of microelectronic devices for applications of interest to military programs.

PHASE II: Design, fabricate, and perform experimental validation/optimization of microelectronic devices utilizing optoelectronic interconnects suitable for military satellite application. Our expectation is an overall improvement of off-module and bisectional bandwidth relative to wire-based approaches. Demonstrate the resulting device(s) to (Air Force/Contractor mutually agreeable) criteria.

PHASE III DUAL USE APPLICATIONS: Photonically interconnected microelectronic devices will certainly be of interest to designers of DoD, NASA and commercial systems including satellites, aircraft, ships, armored vehicles, etc. Photonic interconnects applicable to military satellites can be cost effectively redesigned for commercial use.

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KEYWORDS: Interconnects, Polymer, Wireless, Data communications, Optical, Photonic.

AF02-037 TITLE: Novel High Current Switch for Spacecraft Power Bus Control

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop technology and infrastructure for manufacturing novel high current switches for spacecraft power control applications.

DESCRIPTION: The ability to eliminate high current spikes in spacecraft power bus can provide additional safety margins to system power design. Solid state electrically activated switches have been used in many spacecraft power bus control circuits. For this type of device, the switching time can be an issue at high current levels. A large array of micro-triodes fabricated from chemical vapor deposited diamond micro-tip cold cathode emitters and self-aligned gates will have very high current handling capability, fast switching time, and low grid voltage characteristics. This SBIR topic seeks innovative concepts for developing novel high current switches based on micro-triode array technology. The goal is to develop small, compact (1.25 cm in diameter) switches that can handle 1,000 amperes and have a switching time less than 1 nanosecond with a cut off voltage less than 10 volts. The initial phase of the program calls for the development of prototypes to demonstrate the feasibility of the proposed concepts to meet the critical spatial and electrical requirements. Proposals should include provisions to test and determine the long-term reliability (space qualification) of the developed switches.

PHASE I: Design and build prototypes to demonstrate the ability of the proposed switches to turn off a maximum amount of current in a minimum amount of time. The desired goal is to switch off 1,000 amperes in less than 1 nanosecond, using a switch of less than 10 volts. Development of a protocol to test the developed switches for eventual space qualification is a critical Phase I product.

PHASE II: Finalize switch design and develop an infrastructure for the production of the switches. The emphasis of the Phase II effort is on verifying the performance of switches based on the phase one concept. Establishing a path for space-qualification will be critical part of Phase II effort.

PHASE III DUAL USE APPLICATIONS: Ultra-fast switches that can handle high currents will have many commercial applications in pulsed power circuits and power bus conditioning and surge arresting devices.

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KEYWORDS: Power bus control, Spacecraft power bus, Micro-vacuum tubes, Diamond micro-tips, Mrico-triodes, Cold cathode emitters

AF02-038 TITLE: Integrated Thin Film Solar Array and Phased Array Antenna

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a combination thin film solar array/integrated phased array antenna on the same substrate.

DESCRIPTION: Conventional antenna arrays and power systems utilize separate structures to mount the solar array and antenna subsystems. This results in increased weight for the additional support structures. Thin film solar arrays, because of their low conversion efficiencies, can require large areas to provide sufficient power. A portion of this area, however, could be utilized as a distributed phased array antenna by laying down multiple antenna patterns through some means such as etching an antenna printed circuit pattern (or by some other technique on) the polymer substrate of the solar array. Connection to both the thin film solar array and the antenna could be done through separate multilayer flexible circuitry embedded in the same polymer substrate of the thin film solar array.

PHASE I: Phase I activities shall include (but not be limited to): 1) investigate appropriate antenna pattern designs and related RF frequencies that would be applicable to integration into a thin film solar array substrate, 2) develop a feasible technique for applying the antenna pattern to the thin film solar array substrate, 3) develop a computer simulation of the resulting assembly, 4) demonstrate the operation of the unit by simulation and appropriate level demonstrations.

PHASE II: Phase II activities/deliverables shall include: 1) design/build a functional model of a thin film solar array/integrated antenna circuit assembly 2) develop a functional block diagram for simultaneous/parallel multi-unit operation, 3) demonstrate simultaneous solar cell/antenna operation to mutually acceptable target specifications and operational scenarios.

PHASE III DUAL USE APPLICATIONS: A combination antenna/power system assembly is applicable/advantageous to DoD/commercial space vehicles. It is expected that the first applications of a thin film solar array/integrated antenna circuit will be in small experimental satellites. Terrestrial dual use applications might be in lightweight portable communication devices where a combination of solar and battery power would provide extended usage.

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KEYWORDS: Solar Cells, Phased Array Antenna, Micro-Circuits, Polymer/Polyimide Materials, Multilayer Flexible Circuitry, Antenna Printed Circuit

AF02-039 TITLE: High Efficiency Non-Vacuum Processed Thin-Film Photovoltaics

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop/validate innovative design concepts for forming thin-film photovoltaic devices on polymer substrates

DESCRIPTION: Future DoD/commercial space missions will require photovoltaic devices having specific power ratings in excess of 1000w/kg. Conventional crystalline photovoltaic technology cannot provide these specific power ratings due to the fact that the solar input is only 0.135 w/cm2 and the mass of crystalline devices are approximately 0.125g/cm2. Thus crystalline photovoltaic devices, even with 40% efficiency, have a specific power rating of

approximately 400w/kg. Thin film devices (which have effective area density equal to the substrate) have the potential of providing higher specific power ratings. Presently thin film photovoltaic devices are fabricated using vacuum deposition processes, which grow the photovoltaic devices at relatively high temperatures. Stainless steel substrates accommodate the high fabrication temperatures required for high efficiency devices (greater than 10% AM0 [Air Mass of zero]); however, the use of stainless steel as a substrate for thin film photovoltaics has a number of drawbacks which adversely impact the overall specific power of the resulting solar array. Two drawbacks are: 1) the high density of stainless steel foils and 2) stainless steel substrates preclude implementation of an integrated interconnect system. Amorphous silicon photovoltaic devices have been produced for the terrestrial market using a polyimide substrate with an integrated interconnect system. Maximum efficiency obtained for polyimide substrate production devices is approximately 5% AM1.5. The specific power for these devices is approximately 300w/kg at AM0. To obtain a specific power rating of 1000w/kg an AM0 efficiency of approximately 15% is required. There has been some promising work using a Sol-Gel-like process for forming high efficiency (greater than 10% AM0) thin film photovoltaic devices at low temperatures. This process may allow the use of a wider variety of polymer substrates, which may have lower densities than the polyimides. Devices formed using this process would be capable of implementing an integrated interconnect system. For phase I efforts, a strong emphasis should be placed on the validation of the design that is expected to provide the stated performance enhancements; experimental and theoretical methods should be considered. Government/commercial test and evaluation facilities may be available; via documented requests (to appropriate organizations) to secure these facilities. Based on the results of these tests/evaluations, the performance of the thin film solar cells on polymer substrate should be estimated and improvements quantified.

PHASE I: Develop/validate innovative processes for producing space based, long life, high specific power (1000w/kg) thin film, solar cells fabricated at low temperature (<300oC) on low density polymer substrates. Provide appropriate demonstrations of the products resulting from the selected processes.

PHASE II: Develop/provide a laboratory based prototype demonstration of the solar cell array resulting from the finally selected production process.

PHASE III DUAL USE APPLICATIONS: Dual use commercialization would occur through the development of low cost high efficiency thin film solar cells which could be used for terrestrial/space applications. The market place for commercial space based/terrestrial solar arrays is strong and growing at a rapid rate.

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KEYWORDS: Energy Conversion Efficiency; Thin Film Solar Cells; Specific Power; Solar Arrays; Polymer Substrate.

AF02-040 TITLE: Parallel-Connected Converters with Innovative Control

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop the control circuitry necessary to provide expandable converter power systems for spacecraft applications

DESCRIPTION: As the need for flexible, scalable space-based power requirements increases, and in an effort to avoid redesign of spacecraft and electric propulsion power systems, a number of concepts have emerged to provide expandable, parallel-connected power converters employing techniques such as maximum power tracking. Such approaches then allow a variety of options with the rest of the power system such as employing standard, modular, power converters that can be connected in parallel. The goal is to provide a single power system design that can meet a range of power requirements for spacecraft and/or electric propulsion power systems. For such a flexible and scalable power system, a need exists for control of such functionality. Depending on the concept, risks of power system failures exist due to a variety of circumstances. Under any circumstance that causes the output voltage of the power system to lose regulation, techniques such as maximum power tracking ensure that the power delivered to the load is at the maximum available power from the solar arrays. Thereby, the control prevents the complete drop out of the system output voltage. Under normal sun insolation and healthy conditions of the array source, the control will not interfere

with the regulation of the system output voltage because the load demand is below the maximum available power of the array source. The expansion capability of the system with such a control provides long-term cost/schedule benefits to the electric propulsion and spacecraft power systems of the next generations. In many cases, Commercial Off-the-Shelf (COTS) power converters [ref. 2] can be employed with such control circuitry to meet space needs.

PHASE I: (1) Determine technical feasibility of existing control designs such as maximum power tracking for use with a shared-bus parallel-connected converter power system. Select, modify, and/or design an existing or novel approach that is best suited for controlling the power system architecture using parallel-connected converters. A primary goal of the approach should be to limit the array voltage ripple to a pre-determined amplitude [ref. 2] at a low fundamental frequency that allows for ease of compliance with conducted/radiated emission requirements. (2) Based on the control approach, determine the system guidelines to achieve robust system stability and reliability. (3) Develop the power system architecture/design to accommodate the interconnection of the power converters, the stable and nearly uniform current-sharing control, and the controller. (4) Validate the concept of the proposed power system architecture and control design with the results achieved from computer simulations and analyses of the system response.

PHASE II: (1) Finalize design of the power system and components (the individual converters, the current-sharing control circuitry, and the controller). (2) Simulate the system design and circuits through computer simulation and/or other analysis, to validate the design feasibility down to component level. (3) Generate the detailed schematic diagram of the designed and validated power system (with the current-sharing and control) and document all the design and simulation results. Construct a breadboard system and demonstrate (Air Force/Contractor) mutually agreed basic concepts.

PHASE III DUAL USE APPLICATIONS: The demonstrated feasibility of a highly reliable, cost-effective, high-power, active-controlled, COTS parallel-connected power converter system will attract DoD and commercial industry to apply the concepts in a wide range of future space power system and electric propulsion system applications.

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KEYWORDS: Power Converters, Electric Propulsion, Spacecraft Power Systems, Solar Arrays, Parallel Connected Modular Converters

AF02-041 TITLE: Advanced 10 Kelvin Cryogenic Cooling Technology

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop 10 Kelvin cryocooler technology and multistage cooler technology for next generation spacecraft cooling applications.

DESCRIPTION: Next generation space infrared sensing technologies and spacecraft cryocooling needs will require revolutionary improvements in low temperature cryogenic cooling technology. Advanced infrared cooling systems will take advantage of the developments in doped silicon focal plane technology for improved system performance. However, to utilize the doped silicon FPAs, strides must be made toward advanced, space qualifiable and affordable 10 Kelvin cooling systems. Although numerous technologies have shown the capability to reach 10 Kelvin and provide periodic to continuous useful cooling, these devices are not suitable for space use - i.e. too massive, too inefficient, too unreliable and unable to meet mission lifetime requirements. Examples include periodic (duty cycle) closed cycle hydrogen sorption coolers, continuous closed cycle Stirling cycle coolers, and pre-cooled closed cycle Joule-Thomson cycle coolers. To efficiently achieve 10 Kelvin, many techniques utilize multistage cryocooler and multistage cryogenic

cooling methodologies that offer large potential gains in cooling efficiency and cryogenic system optimization. Multistage cooling differs greatly from typical single stage cryogenic coolers and has a host of technical difficulties associated with the development of robust cryocoolers. Current systems reley on state of the art (SOA) technology that employs cooling at a single cryogenic temperature, necessitating the need for multiple coolers for the different cooling requirements such as the sensor, aft optics, and fore optics. If redundancy is required, then the number of cooler needed doubles to six and imposes significant system mass and power penalties on the spacecraft. One multistage cooler would potentially be capable of performing the same function as several single stage coolers. Improvements in current SOA technology range from reduction in overall system mass, large reductions in system power consumption, and large system reliability improvements by reducing the number of coolers needed and offering unique system redundancy schemes. In addition, technology challenges over the SOA such as temperature stability, variable loading, manufacturability, robustness for space application, and longevity increase the difficulty of the development of multistage cryogenic cooling systems. Examples of cooling technology include, but are not limited to, advanced multistage Stirling, pulse tube, reverse Brayton, multi-component multistage vapor compression, and Joule-Thomson thermodynamic cooling cycles that have the ability to absorb multiple continuous (100% duty cycle) cryogenic heat loads at different temperatures and reject heat to a single heat sink (300 Kelvin). Continuous cooling loads of interest include 0.25 to 1.0 Watts at 10 Kelvin with multistage cooling loads at 35 Kelvin, 60 Kelvin, and 95 Kelvin. Candidate technologies should utilize Phase I for exploitation, design, and concept development of advanced technology and innovative ideas. Phase II should carry the concept from Phase I to breadboard demonstration of the innovation. Phase III should continue the technology development to advanced levels that address real world system issues. Phase II and III goals should be to achieve minimal to no moving parts, minimal mass, minimal input power, minimal vibration, minimal system impact, high efficiency, and high reliability.

PHASE I: Concentrate on the design, analysis, development and / or demonstration the innovative concept or technology. This would include the development of the concept to show how the innovation or technology can be utilized in a cryogenic space system. This effort should include plans to further develop and exploit this technology in Phase II.

PHASE II: Design/develop/construct breadboard device. This device should demonstrate the ability of the innovation or concept to address Air Force technology development needs. Demonstration of the potential improvements in mass, input power, efficiency, reliability, and/or cryogenic system integration should be included in the effort. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort. Phase III should carry the development to advanced operational prototype levels that address real world system issues for potential technology insertion into current and/or future Air Force systems.

PHASE III DUAL USE APPLICATIONS: Applications of this technology could potentially be far reaching. Typical AF and DoD military space applications relate to infrared sensing, cryogen management, electronics cooling, and superconductivity. Phase III opportunities exist for the transition of this technology to emerging Air Force programs with advanced space-based imaging requirements. Including NASA, civil, and commercial users, user applications include missile tracking, surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring. The need for high reliability cryocoolers for terrestrial applications includes cellular bay station cooling and magnetic resonance imaging. If the developed innovation is low cost, potential applications include cmos (complimentary metal-oxide semiconductor) cooling of workstations and personal computers.

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3. Michael Rich, Marko Stoyanof, Dave Glaister, "Trade Studies on IR Gimbaled Optics Cooling Technologies," IEEE Aerospace Applications Conference Proceedings, v 5, p 255-267, Snowmass at Aspen, CO, 21-28 Mar 1998.
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KEYWORDS: Cryocooler, Space, Cryogenic Refrigerator, 10 Kelvin, Infrared Sensors, Cryogenics, Thermal Management, Low Temperature, Multi-stage

AF02-042 TITLE: Advanced Component Technology for Next Generation Cryocoolers

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop advanced heat exchanger, regenerator, and long-life, high-pressure ratio compressors for advanced cryogenic cooling systems.

DESCRIPTION: Next generation space infrared sensing technologies and spacecraft cryocooling needs will require revolutionary improvements in cryocooling technology. Many different techniques have been reported that have potential for marked improvement in cryogenic cooling technology. Examples include use of microelectromechanical systems (MEMS) technology, hybrid thermodynamic cooling cycles, highly effective and miniaturized counterflow heat exchangers, low temperature - high capacity regenerators, and long life, high pressure ratio DC flow compressors. MEMS technology and advanced manufacturing techniques have potential for use in minaturized coolers and as advanced heat exchangers that have applications in many cooling concepts including advanced reverse Brayton coolers, Joule-Thomson coolers, and hybrid expansion cycle coolers. The enabling characteristics of the heat exchangers are high effectiveness (>0.99) combined with low pressure drop and minimal mass and volume. Regenerators are utilized in Stirling cycle based cryocooler technologies (includes pulse tube technology). Low temperature regenerators suffer from the lack of heat capacity compared to the working gas at very low temperatures. It has been demonstrated that materials with magnetic phase transitions at low temperature offer potential benefits to regenerator technology, however new improvements in material science, manufacturability, robustness, and optimum geometry still need to be explored. In addition, high capacity regenerators for applications such as high capacity cooling at 10 Kelvin (500mW to 1W) and 35 Kelvin (3-10W) require innovative designs to enable efficient regeneration for the larger capacity heat loads. Long life (> 10 years, 100% duty cycle), high pressure ratio (4-6:1), DC flow (unidirectional flow) compressors are needed to enable the use of hybrid cooling systems that utilize a higher temperature cryocooler for pre-cooling and cool to low temperatures via a Joule-Thomson or other expansion cooling cycle. These key technology developments will enable future cryogenic cooling technologies and offer significant leaps in efficiency, performance, low temperature capability, and lifetime. Candidate technologies and concepts should utilize Phase I for exploitation, design, and concept development of advanced technology and innovative ideas. Phase II should carry the concept from Phase I to breadboard demonstration of the innovation. Phase III should continue the technology development to advanced levels that address real world system issues. Phase II and III goals should be to achieve minimal to no moving parts, minimal mass, minimal input power, minimal vibration, minimal system impact, high efficiency, and high reliability. These technologies are essential to meet future cryogenic cooling goals for increasingly compact / higher density Air Force and Department of Defense infrared sensing payloads.

PHASE I: Concentrate on the design, analysis, development and / or demonstration the innovative concept or technology. This would include the development of the concept to show how the innovation or technology can be utilized in a cryogenic space system. This effort should include plans to further develop and exploit this technology in Phase II.

PHASE II: Design/develop/construct breadboard device. This device should demonstrate the ability of the innovation or concept to address Air Force technology development needs. Demonstration of the potential improvements in mass, input power, efficiency, reliability, and/or cryogenic system integration should be included in the effort. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort. Phase III should carry the development to advanced operational prototype levels that address real world system issues for potential technology insertion into current and/or future Air Force systems.

PHASE III DUAL USE APPLICATIONS: Applications of this technology could potentially be far reaching. Typical AF and DoD military space applications relate to infrared sensing, cryogen management, electronics cooling, and superconductivity. Potential Phase III opportunities exist for the transition of this technology to emerging Air Force programs with advanced space-based imaging requirements. Including NASA, civil, and commercial users, user applications include missile tracking, surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring. The need for high reliability cryocoolers for terrestrial applications includes cellular bay station cooling and magnetic resonance imaging. If the developed innovation is low cost, potential applications include CMOS (complimentary metal-oxide semiconductor) cooling of workstations and personal computers.

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1. G. E. Cruz, R. M. Franks, "MODIL Cryocooler Producibility Demonstration Project Results," Sponsor: Department of Energy, Washington DC, Report No.: UCRL-ID-112216, 24 Jun 93, 56p. Available through NTIS at 1-800-553-NTIS; NTIS No.: DE93019213.
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3. Michael Rich, Marko Stoyanof, Dave Glaister, "Trade Studies on IR Gimbaled Optics Cooling Technologies," IEEE Aerospace Applications Conference Proceedings, v 5, p 255-267, Snowmass at Aspen, CO, 21-28 Mar 1998.
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KEYWORDS: Cryocooler, Space, Cryogenic Refrigerator, Regenerator, Infrared Sensors, Cryogenics, Heat Exchanger, Low Temperature, Compressor

AF02-043 TITLE: Advanced Multi-stage Cryogenic Cooling Technology

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop multistage cryocooler technology for next generation spacecraft cooling applications.

DESCRIPTION: Next generation space infrared sensing technologies and spacecraft cryocooling needs will require revolutionary improvements in cryocooling technology. Multistage cryocoolers and multistage cryogenic cooling methodologies offer large potential gains in cooling efficiency and cryogenic system optimization. Multistage cooling differs greatly from typical single stage cryogenic coolers and has a host of technical difficulties associated with the development of robust cryocoolers. Current systems reley on state of the art (SOA) technology that employs cooling at a single cryogenic temperature, necessitating the need for multiple coolers for the different cooling requirements such as the sensor, aft optics, and fore optics. If redundancy is required, then the number of cooler needed doubles to six and imposes significant system mass and power penalties on the spacecraft. One multistage cooler would potentially be capable of performing the same function as several single stage coolers. Improvements in current SOA technology range from reduction in overall system mass, large reductions in system power consumption, and large system reliability improvements by reducing the number of coolers needed and offering unique system redundancy schemes. In addition, technology challenges over the SOA such as temperature stability, variable loading, manufacturability, robustness for space application, and longevity increase the difficulty of the development of multistage cryogenic cooling systems. Examples of cooling technology include, but are not limited to, advanced multistage Stirling, pulse tube, reverse Brayton, multi-component multistage vapor compression, and Joule-Thomson thermodynamic cooling cycles that have the ability to absorb multiple continuous (100% duty cycle) cryogenic heat loads at different temperatures and reject heat to a single heat sink (300 Kelvin). Emerging multistage cooling needs range from dual load requirements such as 2 Watt at 35 Kelvin and 6 Watts at 85 Kelvin or 6 Watts at 80 Kelvin and 10 Watts at 150 Kelvin to three or more stages of cooling to meet system requirements for advanced infrared sensing and cooled optic systems. Phase I of the program should focus on exploitation, design, and breadboard demonstration of advanced technology with the potential for refinement in Phase II and III. Phase II and III will focus on achieving minimal to no moving parts, minimal mass, minimal input power, minimal vibration, high efficiency, and high reliability. All of these system attributes are essential to meet multistage cryocooling goals for increasingly compact / higher density Air Force and Department of Defense infrared sensing payloads.

PHASE I: Concentrate on the development and demonstration the innovative technology in a breadboard format. This should include demonstration of a fundamental physical principle in a format that illustrates how this technology can be utilized in a cryocooler or as a cryocooler. This effort should include plans to further develop and exploit this technology in Phase II.

PHASE II: Design/develop/construct an operational prototype device or cooler. This device may not be optimized to flight levels, but should demonstrate the ability of the working prototype device to meet mutually (Air Force/contractor) agreed operational specifications. Demonstration of the potential improvements in mass, input power, efficiency, reliability, and/or cryogenic system integration should be included in the effort. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort.

PHASE III DUAL USE APPLICATIONS: Applications of this technology could potentially be far reaching. Typical AF and DoD military space applications relate to infrared sensing, cryogen management, electronics cooling, and superconductivity. Potential Phase III opportunities exist for the transition of this technology to emerging Air Force programs with advanced space-based imaging requirements. Including NASA, civil, and commercial users, user applications include missile tracking, surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring. The need for high reliability cryocoolers for terrestrial applications includes cellular bay station cooling and magnetic resonance imaging. If the developed innovation is low cost, potential applications include CMOS (complimentary metal-oxide semiconductor) cooling of workstations and personal computers.

REFERENCES:
1. G. E. Cruz, R. M. Franks, "MODIL Cryocooler Producibility Demonstration Project Results," Sponsor: Department of Energy, Washington DC, Report No.: UCRL-ID-112216, 24 Jun 93, 56p. Available through NTIS at 1-800-553-NTIS; NTIS No.: DE93019213.
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KEYWORDS: Cryocooler, Space, Cryogenic Refrigerator, Multi-stage, Infrared Sensors, Cryogenics, Thermal Management

AF02-044 TITLE: Advanced Thermal Integration Technology for Space Cryocoolers

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop cryogenic and ambient thermal integration technology to enable efficient system integration of space cryocooler technology.

DESCRIPTION: Next generation space infrared sensing technologies and spacecraft cryogenic and ambient temperature cooling needs will require revolutionary improvements in thermal storage, thermal switching, high cryogenic and ambient heat flux applications, and thermal transport. Specific examples of thermal transport issues include very long cryogenic transport distances of 1-3 meters and flexible cryogenic and ambient heat transport technology to enable cooling across advanced 2 axis gimbals. Cryogenic applications involve locating the cryocooler remotely on the main body of the spacecraft and cryogenically cooling across an advanced 2 axis gimbal to cool optics or sensors. Ambient applications include removing ambient temperature waste heat from coolers or electronics on gimbal, across the 2 axis gimbal, and transporting the heat to radiators located on the main body of the spacecraft. Technology requirements include the capability for reliable long life operation (10 million+ full gimbal motion cycles), +/- 200° azimuth, +/- 90° elevation, induced torque < 10 in-oz, cryogenic heat transport of 10-20 Watts at 95 Kelvin or 3-6 Watts at 60 Kelvin, ambient heat transport of 200-300 Watts at 300 Kelvin. High heat flux applications include cooling 10s of watts at 35 Kelvin and up to 150 watts at 100 Kelvin with cooler interfaces of < 9 cm^2 and ambient cooling applications where 600 – 1000 watts of waste heat at 300 Kelvin must be extracted from interfaces with < 200 cm^2. Potential technology candidates include loop heat pipes, capillary pumped loops, heat pipes, active pumped loops, heat pumps, reverse Brayton cooler technology, and hybrid Joule-Thomson cooling systems. Candidate technologies should utilize Phase I for exploitation, design, and concept development of advanced technology and innovative ideas. Phase II should carry the concept from Phase I to breadboard demonstration of the innovation. Phase III should continue the technology development to advanced levels that address real world system issues. Phase II and III goals should be to achieve minimal to no moving parts, minimal mass, minimal input power, minimal vibration, minimal system impact, high efficiency, and high reliability. Flexible cryogenic and ambient cooling is essential to meet emerging requirements for advanced systems and is enabling technology for increasingly compact / higher density Air Force and Department of Defense infrared sensing payloads.

PHASE I: Concentrate on the design, analysis, development and / or demonstration the innovative concept or technology. This would include the development of the concept to show how the innovation or technology can be utilized in a cryogenic space system. This effort should include plans to further develop and exploit this technology in Phase II.

PHASE II: Design/develop/construct breadboard device. This device should demonstrate the ability of the innovation or concept to address Air Force technology development needs. Demonstration of the potential improvements in mass, input power, efficiency, reliability, and/or cryogenic system integration should be included in the effort. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort. Phase III should carry the development to advanced operational prototype levels that address real world system issues for potential technology insertion into current and/or future Air Force systems.

PHASE III DUAL USE APPLICATIONS: Applications of this technology could potentially be far reaching. Typical AF and DoD military space applications relate to infrared sensing, cryogen management, electronics cooling, and

superconductivity. Potential Phase III opportunities exist for the transition of this technology to emerging Air Force programs with advanced space-based imaging requirements. Including NASA, civil, and commercial users, user applications include missile tracking, surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring. The need for high reliability cryocoolers for terrestrial applications includes cellular bay station cooling and magnetic resonance imaging. If the developed innovation is low cost, potential applications include CMOS (complimentary metal-oxide semiconductor) cooling of workstations and personal computers.

REFERENCES:

1. G. E. Cruz, R. M. Franks, "MODIL Cryocooler Producibility Demonstration Project Results," Sponsor: Department of Energy, Washington DC, Report No.: UCRL-ID-112216, 24 Jun 93, 56p. Available through NTIS at 1-800-553-NTIS; NTIS No.: DE93019213.
2. R. C. Bowman Jr., B. D. Freeman, et al., "Design and Evaluation of Hydrogen Joule-Thomson Sorption Cryocoolers," Proceedings of the International Absorption Heat Pump Conference, New Orleans 19-21 Jan 1994, p. 265-271.
3. Michael Rich, Marko Stoyanof, Dave Glaister, "Trade Studies on IR Gimbaled Optics Cooling Technologies," IEEE Aerospace Applications Conference Proceedings, v 5, p 255-267, Snowmass at Aspen, CO, 21-28 Mar 1998.
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KEYWORDS: Heat Pipe, Space, Cryogenic Refrigerator, Flexible Lines, Infrared Sensors, Loop Heat Pipe, Thermal Management, Low Temperature, Capillary Pumped Loop

AF02-045 TITLE: Large Focal Plane Array Cryogenic Integration Technology

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop cryogenic integration technologies to enable use of large format focal plane array sensors.

DESCRIPTION: Advanced space based infrared sensing systems will require significant advances in cryogenic integration technologies. Emerging mission requirements for large format or tiled focal plane arrays for infrared sensing applications are driving future cryogenic cooling and integration requirements. These large arrays, potentially 1026 x 1026 pixels and beyond, will require high capacity cooling and a host of cryogenic integration technologies including thermal storage, multiple interface cryogenic links, passive and active cryogenic heat transfer systems, fine temperature stability, low temperature gradient, and fine temperature control across large cryogenic interfaces. Examples of potential cryogenic integration requirements for thermal storage include modular and integral thermal storage units with potential aluminum or beryllium thermal interfaces that are capable of 1500 Joules at 10 Kelvin, 50000 Joules at 35 Kelvin, or 150000 Joules at 60 Kelvin. System needs also include multiple cryogenic interfaces with technical hurdles such as large interfaces (potentially 625 cm^2), tiled FPA assemblies each requiring cooling, low thermal resistance thermal interfaces, and highly flexible thermal interfaces. Cryogenic heat transfer needs include robust, long life potential technology that can accommodate redundant systems with minimal parasitic heat penalties, peak heat loads at 10 Kelvin of 1.5 Watts, peak heat loads at 35 Kelvin of 10 Watts, or peak heat loads at 60 Kelvin of 20 Watts. This also includes temperature stability of < 0.1 Kelvin per minute and temperature gradients of < 0.1 Kelvin gradient across the FPA. Cryogenic integration technology is enabling for exploitation of emerging concepts for future space based infrared systems. Candidate technologies should utilize Phase I for exploitation, design, and concept development of advanced technology and innovative ideas. Phase II should carry the concept from Phase I to breadboard demonstration of the innovation. Phase III should continue the technology development to advanced levels that address real world system issues. Phase II and III goals should be to achieve minimal to no moving parts, minimal mass, minimal input power, minimal vibration, minimal system impact, high efficiency, and high reliability. Cryogenic integration technologies capable of meeting advanced requirements are essential to support future Air Force and Department of Defense infrared sensing payloads.

PHASE I: Concentrate on the design, analysis, development and / or demonstration the innovative concept or technology. This would include the development of the concept to show how the innovation or technology can be utilized in a cryogenic space system. This effort should include plans to further develop and exploit this technology in Phase II.

PHASE II: Design/develop/construct breadboard device. This device should demonstrate the ability of the innovation or concept to address Air Force technology development needs. Demonstration of the potential improvements in mass, input power, efficiency, reliability, and/or cryogenic system integration should be included in the effort. The contractor

should keep in mind the goal of commercialization of this innovation for the Phase III effort. Phase III should carry the development to advanced operational prototype levels that address real world system issues for potential technology insertion into current and/or future Air Force systems.

PHASE III DUAL USE APPLICATIONS: Applications of this technology could potentially be far reaching. Typical AF and DoD military space applications relate to infrared sensing, cryogen management, electronics cooling, and superconductivity. Potential Phase III opportunities exist for the transition of this technology to emerging Air Force programs with advanced space-based imaging requirements. Including NASA, civil, and commercial users, user applications include missile tracking, surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring. The need for high reliability cryocoolers for terrestrial applications includes cellular bay station cooling and magnetic resonance imaging. If the developed innovation is low cost, potential applications include cmos (complimentary metal-oxide semiconductor) cooling of workstations and personal computers.

REFERENCES:
1. G. E. Cruz, R. M. Franks, "MODIL Cryocooler Producibility Demonstration Project Results," Sponsor: Department of Energy, Washington DC, Report No.: UCRL-ID-112216, 24 Jun 93, 56p. Available through NTIS at 1-800-553-NTIS; NTIS No.: DE93019213.
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5. Bugby, D., P. Brennan, T. Davis, et. al, "Development of an Integrated Cryogenic Bus for Spacecraft Applications," Space Technology and Applications International Forum (STAIF-96), Albuquerque, NM (1996).

KEYWORDS: Cryogenic Heat Transfer, Space, Cryogenic Refrigerator, Cryogenic Integration, Infrared Sensors, Cryogenics, Thermal Management, Low Temperature, Thermal Storage

AF02-046 TITLE: High-Performance HgCdTe VLWIR Photovoltaic Detectors

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop innovative methods to decrease the dark current and improve the detectivity of HgCdTe very long wavelength infrared (VLWIR) photovoltaic detectors.

DESCRIPTION: HgCdTe VLWIR (14 micron and longer cutoff wavelength) photovoltaic detectors with high performance are necessary for a variety of US Air Force missions. For this reason, at the present time many organizations are actively pursuing research and development 1-3 of HgCdTe VLWIR photovoltaic detectors. However, the performance of these detectors rapidly decreases as the cut off wavelength is increased, due to rapid increase in the dark current. Hence there is a need to develop innovative methods to decrease the dark current and improve the detectivity of HgCdTe VLWIR photovoltaic detectors.

PHASE I: The contractor will explore one or more innovative solutions to decrease the dark current and improve the detectivity of HgCdTe VLWIR photovoltaic detectors operating at 40-77K. Conduct laboratory scale experiments to demonstrate the viability of the proposed solution.

PHASE II: The contractor will pursue the innovation found to be most promising in phase I, in order to develop HgCdTe VLWIR photovoltaic detectors exhibiting performance better than current state-of-the-art. The contractor will develop demonstration devices and small arrays, and evaluate their performance.

PHASE III DUAL USE APPLICATIONS: Military applications of HgCdTe VLWIR detectors include improved space surveillance and threat warning capabilities, where the ability to detect faint objects at great distances is critical. Commercial applications include industrial and auto- emission monitoring, tumor detection, environmental monitoring, fire and volcano detection etc.

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KEYWORDS: HgCdTe, VLWIR, Infrared, photovoltaic, dark current, detectivity

AF02-048 TITLE: Advanced Algorithms for Exploitation of Space-Based Imagery

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Development of innovative algorithms to optimize detection, identification and tracking of objects in structured environments.

DESCRIPTION: The Air Force Research Laboratory's Advanced Optical Technologies Branch (AFRL/VSBT) solicits innovative algorithms for the mitigation of clutter effects in order to optimize the performance of space-based optical (visible and infrared) reconnaissance and surveillance systems. It is expected that new, signature-based, object-detection algorithms will be developed and tested. Figures of Merit in assessing algorithm effectiveness include improvements in material identification, enhanced probability of object detection in structured backgrounds and reduced probability of false alarms.

PHASE I: Develop advanced algorithms for clutter mitigation / contrast enhancement, using optical data (visible and infrared) from airborne and space-based sensors, to optimize detection, identification and tracking of objects of interest in structured environments. Validate and optimize algorithms. Compare and contrast the candidate algorithms developed.

PHASE II: Demonstrate the efficacy of the algorithms developed in Phase I for detection, identification and tracking of objects in structured environments using field data. Develop and demonstrate an automated, near-real-time, prototype processing system to assess the effectiveness of the target detection, identification and tracking algorithms developed and validated using real-world data sets.

PHASE III DUAL USE APPLICATIONS: The novel algorithms and processing techniques developed under this effort will find application in Phase III in military systems requiring autonomous stand-off detection of objects in the presence of sensor clutter induced by scene structure and the data-collection process, and by spectral interferences. The algorithms will potentially also be useful in non-military applications requiring autonomous detection of objects of interest under similar conditions of scene-induced and sensor-induced clutter and noise, and spectral interferences. Potential commercial applications include processing systems for object detection, and characterization and tracking in fields such as medicine, industrial processing and quality control.

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KEYWORDS: Multi-spectral, Hyper-spectral, Ultra-spectral, Visible, infrared, Data analysis, Data processing, Algorithms

AF02-050 TITLE: Small Launch Vehicle Technology

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop innovative Small Launch Vehicle technologies that provide cost effective Spacelift solutions for Small-Sat architectures.

DESCRIPTION: As satellite micro-miniaturization technologies show increasing promise in improved mission capability at significantly reduced spacecraft weight and cost, a complementary need will undoubtedly exist for a responsive, cost effective Small Launch Vehicle (SLV). Innovative technologies are being sought that address SLV cost reduction in the areas of avionics, propulsion, airframe and structures, manufacturing, integration, and/or operations. A vehicle focus provides for a structured SBIR technology program: i.e. overarching system requirements that define supporting technology needs. This topic seeks to accomplish the development of enabling technologies for future, cost competitive SLVs capable of deploying small satellites (100-1000lbs.)

PHASE I: Develop a suborbital vehicle conceptual design, traceable to a SLV, whereby specific technology requirements are identified for Phase II cost reduction demonstrations. Develop a cost reduction technology risk mitigation plan that addresses identification, rationale, conceptual design, and test exit criteria of high-risk component(s) that will be ground tested under Phase II.

PHASE II: Refine the design of the suborbital vehicle and carry on the research and development of the selected technology up through the prototype phase. The prototype hardware shall emphasize cost reduction technologies, possessing sufficient design information to fabricate, integrate, and operate the advanced component(s). The contractor shall perform prototype ground test and evaluation of the enabling component (s) per the Phase I technology risk mitigation plan. Phase II shall demonstrate critical cost reduction component(s) that sufficiently demonstrate required subsystem performance and reliability. The government will evaluate this.information to determine whether a follow-on Air Force funding Phase III suborbital flight program is warranted.

PHASE III DUAL USE APPLICATIONS: Dual use applications include target vehicles, sounding rockets, and strap-on boosters. Enabling technologies that evolve from this program are directly traceable to a future, low cost SLV. A low cost SLV would enhance the launching of military tactical satellites for theater Intelligence, Surveillance and Reconnaissance (ISR). A low cost SLV would also enhance the deployment of commercial LEO Communications Constellations (e.g., Store and forward paging communication systems) when compared to the current cost of existing SLVs. Other dual use variants of this technology include booster and/or upper stages systems for larger launch vehicles. If Phase II technical exit criteria are met and commercial and/or government (non-SBIR) program funds are identified for Phase III, the contractor shall design, fabricate, integrate, and flight-test the sub-orbital vehicle as defined under Phases I-II.

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KEYWORDS: Launch Vehicle Design, Sub-Orbital Vehicle, Satellite Micro-miniaturization, Technology Risk Mitigation, Flight Test and Evaluation, Small Launch Vehicle

AF02-051 TITLE: Small Shuttle-Compatible Propulsion Module

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop technologies that emphasize improvements in orbit transfer propulsion safety, performance, and cost reduction that are applicable to a small Propulsion Module (PM) deployed from the Space Shuttle.

DESCRIPTION: The Air Force Space Test Program (STP) requires the ability to raise the orbit of small experimental satellites, deployed from the payload bay of a Space Shuttle, to achieve longer, more useful missions. A critical need exists to develop innovative propulsion technologies that simultaneously address NASA Shuttle Hitchhiker Experiment Launch System (SHELS) safety and STP orbit transfer propulsion performance requirements. Due to current technology limitations, no experimental payload has ever been propulsively boosted to higher orbits when deployed from SHELS. The problem is that existing propulsion technologies either do not meet Shuttle safety or STP performance requirements. The objective of this project is to develop propulsion technologies that satisfy SHELS safety while achieving the minimum STP prerequisite orbit transfer performance requirements. Additional technology

considerations necessitate modular, cost effective, and operable propulsion solutions that are commensurate with the SHELS secondary payload environment. The Air Force STP has a minimum propulsion system technology goal that will raise the orbit of a181 kg small payload from a 352 km to a 704 km circular orbit. Of the 181 kg payload, 125 kg is allocated for the experimental satellite, leaving no more than 56 kg for the PM.

PHASE I: The contractor shall develop obit transfer propulsion technologies that are derived from a conceptual PM system design that meets NASA and STP requirements. The contractor shall perform PM performance prediction based on parametric studies for selected technologies and propellant combinations that address the optimal design solution for safety, performance, and cost. A PM technology safety and performance risk analysis is required that: 1) identifies critical propulsion component technologies to be demonstrated in Phase II and 2) a technology risk mitigation plan with discernable exit criteria for government evaluation of high-risk PM components.

PHASE II: The contractor shall design, fabricate, and ground test prototype high-risk PM components identified under Phase I. Contractor PM components will be evaluated against Phase I exit criteria, Shuttle safety, and STP performance requirements.

PHASE III DUAL USE APPLICATIONS: Dual use applications include development of safe, low cost upper stage and orbit transfer technologies for the private sector, while the Air Force STP obtains new operational capabilities for increasing the life span of experimental spacecraft deployed from the Space Shuttle. If Phase II PM components meet all requirements identified in Phase I/II, and government program (non-SBIR) and/or commercial funding is available for a Phase III award, the contractor shall design, fabricate, integrate, and ground test a flight-representative PM. The contractor shall present to the government the PM system design and qualification test results for STP flight approval.

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KEYWORDS: Space Shuttle, Propulsion Module, Orbit Transfer, Spacecraft, SHELS

AF02-052 TITLE: Payload Adapter for Satellite Missions Launched using ICBM-derived Launch Vehicles

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop Payload Adapter Technologies for Satellites that will reduce Spacecraft Launch Costs by enabling multiple payload manifests.

DESCRIPTION: The DoD is interested in developing new low-cost launch vehicles using deactivated ICBMs. The Atlas II, Titan, Taurus (Peacekeeper Stage 0), and Minotaur (Minuteman II Stage 1,2) vehicles are examples of this trend. One of the problems with this approach is that the payload accommodations typically used in ICBMs are designed to hold re-entry vehicles and are inadequate to support satellites. The objective of this project is to develop low-cost, lightweight, modular, payload adapters to manifest multiple satellites on these new launch vehicles. The adapter shall accommodate one large satellite (2000 lb class payload) and have flexibility to carry secondary payloads as well (free-flyer satellites, parasite payloads, and subsystems such as attitude control, power, etc.). Key technologies include, but I are not limited to, material and manufacturing related technologies. Existing materials and composite manufacturing technologies will not be able to meet the structural and mechanism support requirements of satellites/payloads that would be mounted on these new vehicles. The contractor should explore new composite materials, composite materials manufacturing processes, composite/metal joining techniques, re-configurable design issues, and strength/weight optimized composite structures. The contractor is encouraged to identify key technologies that this SBIR topic has not specifically addressed. Technologies developed need to address issues such as reliability, safety, weight, reduced part count, low cost manufacturing, integration, and the configuration flexibility to meet the requirements of a variety of spacecraft/payloads. Associated technologies include payload environmental isolation, low-shock satellite release systems, and accommodations for various subsystems (attitude-control, power, etc.). These technologies are the subject of other AFRL-funded projects already in work. This proposed SBIR project will allow us to incorporate these other technologies into a capability that will facilitate technology transfer of all projects.

PHASE I: Identify materials and manufacturing methodologies compatible with a conceptual design for the multiple payload adapter. Establish a program plan that identifies high-risk technologies that will be demonstrated in Phase II and outlines a strategy to integrate these key technologies into a prototype payload adapter system. The program plan should also include projected costs, and a test plan with discernable exit criteria for government evaluation of high-risk payload adapter components. Key technology risk mitigation efforts should include subscale proof-of-concept demonstrations and analysis that paves the way to scale the technology to a full-scale system. Evaluation of the payload adapter concept will be based upon review of the following parameters : system safety, adapter manufacturing costs and associated touch labor, system mass and volume, launch vehicle integration efficiency for a range of existing launchers, satellite integration efficiency, launch/acoustic/shock load survival.

PHASE II: Design, fabricate, test and demonstrate prototype hardware for the payload adapter system identified in Phase I. The prototype adapter should incorporate as many of the key technologies as possible, depending on available funding. A detailed performance analysis of the technology is also required. If funding allows, the contractor shall support potential launch and integration activities thereof. The demonstration's success will be evaluated in accordance with Air Force specifications, performance, manufacturability, and cost guidelines. A strategy to transition the technologies developed for current and future spacecraft is strongly encouraged.

PHASE III DUAL USE APPLICATIONS: Currently, there are a growing number of small/micro satellites being launched by the government and universities to support small space experiments. However, industry has not adapted to this sudden shift in paradigm from the large single payload to several small payloads. In order to reduce soaring launch costs, DOD, NASA, and the commercial sector has a need to launch small multiple satellites on a single launch vehicle. Military applications include programs such as TechSat 21, XSS-10, and the Air Force's Space Test Program, commercial applications include the small/micro satellites university payloads and experiments that are now being launched. The basic technologies explored in this project (space-qualified composite materials, modular design, composite/composite and composite/metal joining, etc.) have a high potential for spin-off into other aerospace-related programs such as modular satellite structures.

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KEYWORDS: Multiple payloads, Multi-functional, Spacecraft, Low-cost, Mechanisms, Deployment, Separation, Composites

AF02-054 TITLE: Insulated Stainless Steel or Molybdenum Substrate for Thin Film Photovoltaics

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: The goal of this SBIR effort is to develop and enable monolithic integration of thin film photovoltaic cells into series connected strings of cells and likewise enable incorporation of monolithic diode protection into solar arrays.

DESCRIPTION: As a result of the promise of much lower cost per watt and the lower mass per watt produced as compared to monolithic crystalline solar cell technologies, the U.S. Air Force is developing thin film photovoltaic cells and modules for use on high power satellites. For example, one of the key technologies with high potential for satisfying the cost/watt and the watt/kg figures of merit for thin film photovoltaics are the copper indium gallium di-selenide (CIGS) technologies. Thin film solar cells are much less costly than their crystalline counterparts when compared at the cell level, but substantial costs savings can also be realized with thin films by producing large area cells and by monolithically integrating rolls of cells, directly from the fabricating machine, into strings of interconnected cells, thereby eliminating the expensive touch labor that will be required to actually cut cells and weld them together in cell strings. A monolithic production capability will also positively impact yields and provide a more robust cell string, eliminating the human factors present in touch labor processes. Presently, CIGS technologies require relatively high processing temperatures that are too high for optimized processing on polyimides, therefore device fabrication takes place on stainless steel or molybdenum foils. This precludes monolithic device integration such as series connection of solar cells and incorporation of bypass and blocking diodes, processes that are analogous to crystalline solar cell panel and array fabrication and accepted industry practice, because the device is produced on a

conductive substrate and simple etching procedures cannot expose an insulating or conductive layer to isolate or interconnect cells with relative ease. The key to implementing monolithic processes is incorporation of an insulating layer between the active cell and the substrate. Monolithic device fabrication has been an extremely difficult feature to incorporate into thin film cells while maintaining performance. There are two distinct avenues to monolithic integration of thin film cells, one is to produce sufficiently high efficient cells on a polyimide, a process that has met with mediocre success to date as a result of low process temperatures, the other is to develop an insulating layer on the metal foil on which cells are presently manufactured. This second method allows thin film cells to be manufactured to the full potential of the technology since all substrate layers must be able to withstand full process temperatures. The use of polyimides could offer the same potential performance of thin film cells on metal foils since even if efficiencies are compromised the substrate mass could be sufficiently reduced to achieve competitive cost per watt and watt per kilogram performance data. Regarding the technical risk of the effort, this can be measured by past efforts of industry to develop and incorporate an insulating layer in the CIGS on metal foil technologies. The risks have been shown to reside in the ability to match the coefficient of thermal expansion between the insulating layer and the CIGS, providing a pinhole free layer over a large area, and in providing a layer that resists de-lamination. Thin film, low cost photovoltaic devices are becoming increasingly attractive to consumers as an alternative to obtaining power from the grid. Recent events in California where power costs have skyrocketed due to the ever increasing demand for power and the difficulty of power companies to obtain building permits for new power stations due to environmental regulations have resulted in no new plants being built for a long period of time, and any new plants will take years to build. This has created a vacuum in power production that thin film photovoltaics could fill if the price is right. Success in efforts such as this one that drive the cost of production down and result in robust cell strings will create significant revenues for an enterprising business. Roll to roll manufacture of thin film technologies have been successful to date, however, there is still much touch labor in making strings of cells to produce high operating voltages and as always, this labor is expensive and efforts prone to mistakes. This represents a very good opportunity for a small business to enter this market and make a large impact.

PHASE I: A suitable endeavor for phase one would be to identify candidate insulating layers that can be deposited on a stainless steel or molybdenum substrate that show good promise for use as a large area pinhole free insulating substrate with minimum tendency to de-laminate under all operating conditions.

PHASE II: The goal of phase II is to fabricate a string of monolithically integrated cells showing proof of principle, incorporation of diode protection for thin film cells is of secondary importance since it has yet to be shown that such protection is necessary as a result of the soft characteristics of thin film photovoltaics. Using devices of areas consistent with the state of practice:1) Demonstrate large area devices with pinhole free insulating layer. a. Determine de-lamination potential under operating conditions. b. Determine operating characteristics at various temperatures for mismatched CTEs. c. Perform light and dark I-V measurements of cells with insulating layer to ensure that performance has not been compromised. 2) Demonstrate monolithic integration of cells into a string of series connected cells of sufficient number to show proof of concepta. Produce light and dark I-V characteristics of string.b. Operate under simulated array conditions and observe nature of cells in reverse bias conditions. c. Place string under mechanical tension similar to what will be placed on a space based array (information provided by government program manager upon request) and observe operation.Also, it would be ideal, if sufficient funding is available, to demonstrate monolithic construction of bypass and blocking diodes.

PHASE III DUAL USE APPLICATIONS: Commercialization efforts would be focused upon transitioning the laboratory scale processes developed in Phase II to a prototype manufacturing capability. The government application of this technology would be devoted to enabling efficient, cost effective and robust production of cells for the Power Sail and Techsat 21 programs, and the insulating layer can be envisioned for a number of high temperature growth processes for use with sensors and other thin film electronic devices. The commercial application of the results of this program would be to drive the cost of manufacture of thin film photovoltaics down to the point where it is commercially competitive to power from the grid thereby tapping enormous markets. Further, commercial applications for high temperature insulating thin films should be numerous and will depend on the innovativeness of the entrepreneur.

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KEYWORDS: Solar Cells, Power Conversion, Photovoltaics, Solar Cell Arrays, Conversion Efficiency, Flexible Thin Film Photovoltaics

AF02-055 TITLE: Star Trackers Based Upon Advanced Sensor Technologies

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a star tracker based upon space-qualifiable advanced focal plane array technologies

DESCRIPTION: Modern star trackers are based primarily upon Charge-Coupled Device (CCD) image sensors. CCDs are sensitive to the space radiation environment and may degrade rapidly under the influence of energetic particles and photons. Recently, new types of image sensors have been developed that show promise of being more radiation-tolerant than CCDs. These include arrays of various types of photodetectors including photocapacitors, pin-photodiodes, and pn-photodiodes. These devices are sometimes called Active Pixel Sensors (APS) because, in contrast to CCDs, the individual pixels can be addressed. Nonetheless, no commercially available star tracker has been built based upon these devices. The hardware and software required will be substantially different than for star trackers based upon CCDs in order to take advantage of the capabilities of these modern focal plane arrays. For example, photodetector image sensors based upon Complimentary Metal-oxide Semiconductor (CMOS) processing may include features such as on-chip analog-to-digital converters, on-chip correlated double sampling, and addressability of individual pixels. Proposals should indicate how their approach will enable features not currently available on star trackers.
Development/integration of star trackers based upon modern focal plane arrays (not including CCDs) to applications of greatest utility to USAF satellite programs are of high interest.

PHASE I: Develop concepts and models for the hardware and software necessary for the operation of a modern focal plane array (not including CCDs) as star trackers to facilitate features such as on-chip analog-to-digital conversion, on-chip correlated double sampling, and addressability of individual pixels. Phase I activity should consider innovative concepts for the survivability and performance of star tracker components for systems consistent with the use of microelectronic devices for applications of interest to military programs.

PHASE II: Design, fabricate, and perform experimental validation, and optimization, of a prototype star tracker utilizing an advanced radiation tolerant APS focal plane array.

PHASE III DUAL USE APPLICATIONS: Radiation-tolerant star trackers will support a broad range of DoD, NASA, and commercial satellite systems, as well as NASA deep space missions. Advanced star trackers applicable to military satellites can be cost effectively redesigned for terrestrial commercial use.

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KEYWORDS: Star tracker, Focal plane array, Active pixel sensor, Pin-photodiode array, pn-photodiode array, Radiation effects.

AF02-057 TITLE: Polarization Phenomenology Modeling and Simulation

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop new polarization modeling software or develop new polarization instrumentation for use in understanding polarization phenomenology.

DESCRIPTION: AFRL is engaged in research and development to further the understanding of optical polarimetric phenomenology. One advantage of using polarization is that it can improve contrast for a number of object detection and discrimination applications. Emissive polarization can possibly be used to detect an object from background in an isothermal scene where conventional infrared sensors would detect little or no contrast. Of particular interest are the spectral polarization signatures of objects measured passively in outdoor environments. Polarization phenomenology investigations must first start with an understanding of the raw polarization signatures from objects of interest. The emitted and reflected portions of the polarized light depend on the material characteristics of the object, such as surface roughness, index-of-refraction, and object geometry. The overall phenomenological studies must also take into account

environmental variables that affect the polarization signal measured by a detector. Sky illumination is the most significant environmental variable that changes the apparent object signature, but influences of atmospheric propagation may also be present. Because the environment can have a great effect on polarization signatures, modeling and simulation, incorporating material characteristics and environmental variables, will be used to develop a better theoretical understanding of the physics behind measured signatures and to predict polarization signature outdoors. With this in mind, the ability to perform object-to-sensor simulations of polarization measurement scenarios is required. Data from a controlled environment, showing raw polarization signatures, and field data, showing environmental effects, are being collected to validate specific models and the overall simulation. AFRL is requesting proposals in two related areas. First is the development of new polarization modeling software packages that can be used in investigating polarization phenomenology. This package would aid in predicting polarization from surfaces, the atmosphere, or be an integrated predictor of the total polarization measured by a sensor. Second, AFRL is requesting novel approaches to building polarimeters for use in phenomenology studies. The needed polarimeters include full polarization, spectral capability, measure polarization simultaneously, and can be accurately calibrated. Since accurate data is needed for phenomenology, part of the potential effort would include investigating the calibration of the polarimeter system.

PHASE I: Develop approaches for a polarization modeling software package or conceptual designs for a polarimeter suitable for phenomenology studies.

PHASE II: Develop applicable and feasible prototype models, software, or instrumentation using the Phase I results and demonstrate a degree of commercial viability. Prototype software would be used to compare predicted polarization to some measured results. Prototype sensors would demonstrate capabilities and include a detailed plan for calibration.

PHASE III DUAL USE APPLICATIONS: Many military applications will benefit from using optical polarization, and thus will take advantage of the successful completion of the Phase II effort. Remote sensing with polarization has potential applications in the commercial market as well, particularly in improved environmental assessment.

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KEYWORDS: Polarization, Polarimetry, Remote Sensing, Modeling, Simulation, Validation Experiments, Spectral Polarization

AF02-058 TITLE: Geophysical Interpretation of Digital Ionosonde Signatures

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop and demonstrate software and hardware techniques implementing innovative algorithms for extracting key geophysical parameters from digital ionosonde data

DESCRIPTION: Accurate determination of ionospheric conditions including the electron density altitude profile, electric fields, plasma irregularity locations, and irregularity spectral characteristics is essential for the development and reliable operation of many modern ground and space-based communications, navigation, and radar systems, in both military and commercial applications. These geophysical parameters are also critical inputs to space weather monitoring and forecast models developed and operated by the DoD and civilian government agencies. Radio frequency sounding using ionosondes has historically been one of the most versatile and cost-effective means of obtaining ionospheric information, but interpretation of ionosonde data has traditionally required labor-intensive analysis by experienced observers to accurately determine even basic parameters such as the bottom-side density profile. This proposal calls for the development and application of modern digital data acquisition and processing technologies to greatly expand the geophysical information content extracted from the ionospheric sounding process. Basic research has shown that electric fields, waves, neutral winds, neutral composition, horizontal electron density gradients, D region densities, particle precipitation, and both large- and small-scale irregularities are all critical parameters having observable signatures in digital ionosonde data, but this valuable information remains unexploited and unavailable due to the lack of suitable computer algorithms to analyze the data or by limitations in the hardware

used to obtain the data. For example, ionospheric irregularities under high latitude patch and equatorial spread-F depletion conditions could be detected, imaged, tracked and characterized in terms of their location, intensity and spectral characteristics. Precipitating particles in the high latitudes generate ionospheric signatures that can be related to the energy flux of the incoming particles. Development of computer algorithms to extract additional ionospheric parameters or improve the reliability of currently available parameters is a complex task requiring an innovative approach likely to result in development of valuable new signal processing algorithms and enhanced measurement techniques. Software modules implementing these techniques could be incorporated into new sounder systems or licensed for use with the large number of existing ionosondes in operation around the world. Hardware developments could be marketed as a next generation ionosonde. The DoD has significant investment in the field of ionospheric measurement, including archived and current data, field sites, digital ionosonde hardware, and validation sensors. These resources can be made available for adaptation and use in research, testing, and validation of products developed under this topic.

PHASE I: Develop innovative algorithms for automated identification and quantification of significant geophysical parameters from digital ionosonde data. Design any necessary new hardware or hardware modifications.

PHASE II: Produce prototype hardware and software modules implementing the algorithms and techniques produced in Phase 1 and demonstrate their ability to process actual data from high-, mid- and low-latitude ionosondes. Validate the output parameters by comparing to other sensor data where possible.

PHASE III DUAL USE APPLICATIONS: Products based on successful developments in Phase II are expected to greatly enhance the utility, increase operational effectiveness and decrease the cost of existing ground-based ionosonde networks operated by the DoD and allied nations by enhancing hardware and data archives to provide additional parameters for input to space weather models and forecast products. In the civilian and commercial sector, which accounts for 80% of the ionosondes operated worldwide, the technologies could be adapted or ported for incorporation into real-time operating software for new ionosondes, modified and licensed for use with hundreds of existing sounders operating around the world, form the basis for a new generation of advanced ionosondes, or marketed independently of sounder hardware for use in processing ionosonde data archived in global data centers worldwide. The availability of reliable software capable of accurately extracting multiple geophysical parameters from ionosonde data can be expected to boost worldwide demand for ionosondes as the primary ground-based sensors for space weather monitoring and forecast networks. This will benefit the U.S. government as well as other organizations.

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KEYWORDS: ionosonde, plasma, ionosphere, signatures, space weather, radio propagation

AF02-059 TITLE: Smart Membrane Structures

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Model, develop, and demonstrate novel ultra-lightweight curved structures capable of optical precision.

DESCRIPTION: Innovative approaches are sought for developing ultra-lightweight structures capable of optical precision for 10m and greater diameter optical systems. Of primary interest is the blending of ultra-lightweight structures such as membranes with highly innovative sensing and control approaches such as those based on the latest smart materials developments. The ultimate goal is to develop large (10m or greater) optical systems which are lightweight (1kg/m^2 or less areal density), stowable within existing small to medium launch systems, reliable, and cost-effective.Geometric nonlinearities cause large flexible membranes to deviate from an ideal parabolic shape upon deployment. Techniques that have been used to 'correct' the shape have included piezo-polymer (PVDF) films, electrostatic actuation, and net-shape casting of membrane structures. It is envisioned that a newer class of smart materials such as shape-memory films and piezo-ceramic fibers could enable full-surface actuation with greater control authority. The 'Smart Membrane Structure' should also be able to correct itself for mission induced thermal excursions and incorporate active damping.The eventual goal of this technology development is to enable optical imaging, therefore micron or submicron level of surface accuracy is desired, depending on the use of secondary image correction techniques. The ability to detect surface accuracy for very large structures to these levels of precision is also a part of

the design challenge for the successful implementation of the technology. Analytical tools employed towards these goals should be capable of adequately modeling the physical phenomena and correlate with the metrology tools used to validate the models and implement the system.

PHASE I: Analyze recent developments in smart materials and structures to develop a concept appropriate for a smart membrane mirror. Design the necessary deployment, actuation and metrology system. Demonstrate feasibility through analyses and scaled testing.

PHASE II: Finalize the Phase I conceptual design and then based on that design, develop and demonstrate a subscale smart membrane engineering development unit for testing at the Air Force Research Laboratory. Demonstrate traceability of the technology to >10meter diameter optical systems.

PHASE III DUAL USE APPLICATIONS: Large lightweight mirrors will enable space based imaging with significantly greater resolution (few centimeters from LEO orbit). Improved resolution will also address the future needs of NASA's ORIGINS program.

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KEYWORDS: composite, structures, membranes, smart structures, smart materials

AF02-060 TITLE: Long-Stroke Isolation System for Large Flexible Space Structures

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop a lightweight, articulated boom concept for connecting two spacecraft that isolates the spacecraft dynamics while allowing for slewing.

DESCRIPTION: Future concepts for deployment of very large solar arrays and antennas require the dynamic isolation of these large flexible structures from the host spacecraft. This isolation systems will have to meet many demanding requirements including: accommodation of large slewing motions of both spacecraft (e.g. solar arrays tracking the sun, scanning of antennas, etc.), maintain position knowledge and relative placement of spacecraft for collision avoidance, capable of incorporating high-power transmission and data lines, and have efficient packaging and on-orbit deployment.Preliminary analysis has shown that use of lightweight, flexible umbilical connections for isolation and power and data transfer have an inherently high level of risk concerning positioning and the possibility of collision/entanglement between the array/antenna and host spacecraft. To address these shortcomings, a new connection scheme is required to enable attachment of large solar arrays without the risk of collision or entanglement. This concept must be able to not only isolate the flexible dynamics of the large, lightweight structures from the host spacecraft as well as accommodate the large-stroke motions that are generated from the disturbance differential of the spacecraft, but it must also provide a level of certainty in connection position to prevent inadvertent collision during solar array or host spacecraft operations. One possible solution is a multi-link articulated boom with actively controlled joints that is capable of transmitting power and data from the array to the host spacecraft. Such a connection scheme is expected to enable long-stroke motion and isolation of flexible dynamics, as well as provide a means of configuration control.

PHASE I: Establish concept feasibility for lightweight articulated boom capable of positioning and dynamically decoupling a large flexible structure from a host spacecraft. Through modeling and simulation establish rough suitability for space applications based on cost, mass, survivability in space environment, ability to accurately control boom configuration, degree of isolation of flexible dynamics from the flexible structure to the host spacecraft, and compact packaging. Compare the articulated boom concept to traditional array attachment and isolation approaches. Develop a program plan that shall incorporate an implementation strategy/methodology for the new technologies, projected system and subsystem level payoffs, a detailed technical challenge breakdown, risk mitigation strategy,

proposed program schedule, and estimated costs. The primary result of Phase I shall be a well-defined Phase II development and demonstration plan.

PHASE II: Develop and demonstrate prototype hardware for the concept identified in Phase I. Tasks shall include a detailed proof of concept demonstration of key technical parameters, which can be accomplished at a subscale level. A detailed performance analysis of the technology is also required. The demonstration's success will be evaluated in accordance with Air Force specifications, performance, manufacturability, and cost guidelines. A strategy to transition the technologies developed for current and future spacecraft is strongly encouraged.

PHASE III DUAL USE APPLICATIONS: There is significant interest by commercial satellite manufacturers for dramatic increases in on-orbit power. Increased power would increase the number of transponders on each spacecraft resulting in increased profits. The ability to dynamically isolate these arrays is critical in allowing for continued array growth. This technology would also apply to other attached flexible structures such as antennas and to on orbit docking and servicing.

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KEYWORDS: Articulated boomSpacecraft IsolationFlexible Structures ControlSpace Power Generation

AF02-062 TITLE: Autonomous Satellite Cluster Data Fusion

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Design and develop technologies to enable the assimilation of multiple information sources across a satellite cluster and provide intelligent reasoning.

DESCRIPTION: The concept of using clusters of microsatellites to replace large monolithic satellites is a relatively new idea. With this new concept comes many new challenges which include how information is shared across the cluster and how communication with the ground is handled. At the present time there is very little automation on-board Air Force satellites as relates to surveillance payload missions. Large amounts of data are collected from each satellite and downlinked to the ground where a variety of independent techniques are used to assess whether there exists any information of value. In addition there is virtually no collaboration between satellites with respect to each other's position or knowledge about detected objects of interest. The amount of data collected and downlinked could be drastically reduced if more intelligence is placed on-board which has the ability to process, detect, and interpret information on-board the cluster and adjust and/or configure sensors accordingly based on sensor data. The objective of this research effort is to develop an architecture which will enable knowledge sharing across a cluster of satellites. Each satellite in a cluster would have its own on-board satellite manager which would manage activities on-board its own satellite. A higher level cluster manager would reside at a higher level and manage the overall cluster activities. Each satellite's on-board controller would operate autonomously in cooperation with executive controllers on-board other satellites as well as ground-based controllers. Each of these controllers would act as top level intelligent agents. A key to this research effort is the ability of the individual spacecraft managers to cooperate with one another. For example an agent residing on one satellite may detect some object of interest and react accordingly. To optimize information processing, relevant information can be made available to a second satellite such that when the object comes within its field of view it can already be configured to optimize observation of the object in question. The notion of an intelligent cluster manager can be extended to include health and status related satellite autonomy.

PHASE I: Provide a detailed design and description for the architecture which will enable information fusion across a satellite cluster. This will include but not be limited to the following, (1) mechanism by which knowledge is shared, and (2) means by which a situational assessment is made based on the status of information sources. A demonstration of the proposed architecture is highly desired.

PHASE II: Do a detailed implementation of the design generated in phase I and to provide an in depth demonstration of its capability. The architecture should be designed such that it can be easily extended to incorporate new agents as needs arise. Demonstration of this extensibility/flexibility is desired. Demonstrating this technology in an actual flight experiment is ideal, however if time and cost prevent this then the demonstration should be as realistic as possible with an easy migration towards a flight experiment.

PHASE III DUAL USE APPLICATIONS: The concept of data fusion of heterogeneous information sources is not specific to satellite autonomy but has applicability to any number of different domains. Any process which involves

monitoring a number of different entities from different sources and providing a situational assessment based on all of these entities could benefit from such an intelligent architecture.

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KEYWORDS: Satellite Autonomy, Intelligent Decision Making, Cluster Management, Information Fusion

AF02-063 TITLE: Remote Satellite Diagnostics

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Determine the condition of a satellite from external means.

DESCRIPTION: The Air Force is developing technology for future on-orbit maintenance and servicing as well as increased space situational awareness. One of the needs is the ability to remotely or externally diagnose a satellite. What is desired is the ability to determine if satellite subsystems are operating normally. If they are not, one would like to know how they are out of spec and what the cause may be. The capability would be applied to a satellite that did not have sufficient capability for self-diagnostic built in or one where the satellite was unable to communicate to the ground for some reason. Once the problem is determined, a course of action can be planned. The capability would also be useful for determining if other countries satellites were operating as they were reported. For instance, if a country says its satellite has died, the AF could then verify if this is true or not. The types of subsystem information that is desired includes: (if the solar arrays are operating and at what power level, if ACS thrusters are operating as expected, if momentum wheels are operating and are they saturated, what the power draw on the satellite is from its thermal or RF emissions, are the communication antennas operating and what are they broadcasting, what is the activity of the processor and spacecraft electrical bus, what is the level of fuel remaining, what is the condition of payloads such as communication antennas or imaging sensors.) There are a number of means to sense this information. Examples information that may be used includes thermal signatures and gradients, RF signatures, spacecraft motion and jitters, field variations, center of mass changes, and analysis of spacecraft vents, out gassing, and thruster exhaust. This information could be obtained from close from the ground, from close proximity, or from a robotic operation that touches the satellite. The first two options would be preferred. What is sought are innovative concepts and means to perform the remote diagnostic or a piece of the diagnostic. This topic includes new sensors and ways to use sensors to measure the physical characteristics such as RF emissions, field variations, etc. This topic also includes methods and concepts for assimilating the physical information and determining the subsystem and system operating performance.

PHASE I: Define the concept and technologies needed as well as a description of how it will address the military mission. The basic fundamentals will be analyzed and used to determine expected effectiveness and capability of the concept.

PHASE II: Develop the technology and build prototype sensor systems that can be tested in representative environments. Ideally, the phase II effort would include ground testing of the hardware against a real satellite and demonstration that the data synthesis algorithms can diagnose the current operating state.

PHASE III DUAL USE APPLICATIONS: The commercialization potential will be significant for both use as a diagnostic on commercial satellites and for similar uses on earth. The technology could also be used to monitor terrestrial systems that are difficult to reach.

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KEYWORDS: Satellite Maintenance, On-Orbit Servicing, Telerobotic Maintenance, Remote Diagnostics

AF02-064 TITLE: Ground-based Daytime Optical Imaging of the Ionosphere

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop and demonstrate optical imaging instrumentation for observing ionospheric structure from the ground under daylight and twilight conditions.

DESCRIPTION: Optical imaging is one of the few means available to determine the structure of the ionosphere over large areas. However, all-sky imagers and other traditional ground-based optical instruments are limited to operation during periods of complete darkness. In contrast, regions where instability precursor signatures or formation of density irregularities might be observed are often illuminated by daylight or twilight. These situations include generation of plasma plumes over the magnetic equator near sunset and formation of polar cap patches in the cusp on the day side of the auroral zone. Satellite measurements at ultraviolet wavelengths are able to detect aurora and other ionospheric features from space, but are limited by spatial resolution, the revisit rate, and cost of spacecraft operations. Innovative diagnostic instrumentation to allow ground-based imaging of ionospheric structure under daylight and twilight conditions is sought to aid Air Force efforts to monitor and forecast scintillation and other ionospheric effects on communications, navigation and radar systems. Secondary considerations for a successful diagnostic system include instrument portability, reliability, ease of operation and maintainability, remote or automated operation, and the use of commercial off-the-shelf components when available.

PHASE I: Develop a concept for extracting useful ionospheric parameters from the total dayglow signal under realistic ionospheric conditions. Produce a detailed design for an imaging instrument and estimate the sensitivity and temporal and spatial resolution for anticipated observation modes and ionospheric parameters.

PHASE II: Construct and deliver a prototype system, including operating manuals and software. Analyze actual system capabilities and conduct a field test comparing observations with parameters from radars or other ionospheric measurements.

PHASE III DUAL USE APPLICATIONS: A successful instrument developed in Phase II could be used to provide ground-based measurements for C/NOFS or other ionospheric monitoring/forecast systems under development by the DoD. In the commercial sector, the instrument or variants might be expected to find extensive use in environmental monitoring and atmospheric pollution measurements, in addition to direct applications in atmospheric, space, and astronomical research.

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1. Chakrabarti, S., Ground based spectroscopic studies of sunlit airglow and aurora, J. Atmos. Sol.-Terr. Phys., 60, p. 1403, 1998.
2. Rees, D., M. Conde, A.A. Steen, and U. Brändström, The First Daytime Ground-Based Optical Image of the Aurora, Geophys. Res. Lett. Vol. 27 , No. 3 , p. 313, February, 2000.
3. Sridharan, R., D. Pallam Raju, R. Raghavarao, and P. Ramarao, Precursor to equatorial spread-F in OI 630.0 nm dayglow, Geophysical Research Letters, Vol. 21, No. 25, p. 2797, December 15, 1994.

KEYWORDS: airglow, dayglow, ionosphere, thermosphere, upper atmosphere, optical, imaging, plasma density, irregularities

AF02-067 TITLE: Deployable Ceramic Oxygen System

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop an efficient and reliable ceramic oxygen generating system to support aeromedical and On-Board Oxygen Generating System (OBOGS) uses.

DESCRIPTION: Exploratory research will be conducted to advance ceramic oxygen generating technology. The effort will involve research focused on a device for separating oxygen from air using an ion-conducting membrane driven by electric power. Ceramic oxygen generation appears to afford critical advantages for economic and reliable

production of high purity oxygen (99.0%). Primary goals of the effort are miniaturization, and power and weight reduction.

PHASE I: An experimental ceramic oxygen generator will be designed, fabricated, and operated to characterize and optimize a small-scale breadboard device. Advanced electrolyte materials capable of operating below 750°C will be explored. These advanced materials will be pursued because of their lower power requirements and superior separation efficiency when compared to conventional materials, such as zirconia. Electrical interconnect designs will be evaluated with the goal of minimizing electrical resistance/losses. The experimental device will be examined to improve understanding of the general technical issues. Issues to be investigated are: increasing oxygen production, increasing operating pressure, decrease operating temperature, decreasing power required, decreasing size and weight, and improving reliability.

PHASE II: A breadboard ceramic oxygen system will be designed, fabricated, evaluated, and optimized for miniaturization, and power and weight reduction. An effective thermal management approach will be incorporated into the system. The system will be tested and/or analyzed to evaluate oxygen production efficiency, delivery pressure, oxygen purity, long term electrolyte degradation, weight, size, power, producibility, affordability, and reliability. Contract deliverables would include the breadboard system and a final report.

PHASE III DUAL USE APPLICATIONS: Phase III military applications include upgrades to the Deployable Oxygen System currently being developed. Other military uses are replacements for currently deployed on-board oxygen generating systems (OBOGS). Phase III commercial applications include medical applications and industrial applications for high purity oxygen. These would include hospital and home medical use as well as light welding applications.

REFERENCES:

1. Operational Requirements Document, Deployable Oxygen System (DOS), Air Mobility Command, 5 Jan 01 (DRAFT).

2. CRC Handbook of Solid State Electrochemistry, edited by P.J. Gellings and H.J.M. Bouwmeester, CRC Press, 1997.

KEYWORDS: oxygen generation, ceramics, ceramic oxygen generation, life support, ion-conducting membrane, deployable oxygen system, on-board oxygen generating system, OBOGS

AF02-068 TITLE: DMT Training Requirements and Capability Analysis

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Streamline and optimize the TSRA process and associated database to support Distributed Mission Training federation development.

DESCRIPTION: To live up to potential, DMT needs a mission-oriented analysis system that will determine the training impacts of federation additions and changes, and impact of proposed training system enhancements in such areas as visual systems. Current standards allow federation players to interact, but cannot guarantee that interactions will provide effective training and avoid negative transfer of training. The effectiveness of interactions is a function of the accuracy of the models of individual aircraft, sensors and weapons used in the DMT, the accuracy of the representation of the environment through which the players interact; the characteristics of visual systems used on various simulators used in DMT and the fidelity of the force cues provided by these simulators. Since it is not possible to fully reproduce the real world in DMT, the impact of this practical limitation should be understood before new players are added to the Federation or new enhancements are funded. If the impacts of new players or enhancements can be determined, practical requirements can be placed on their real, virtual, or constructive representations. Current Training System Requirements Analyses (TSRAs) do not adequately integrate training needs and technical capability. Current TSRAs are too detailed and complex to provide timely data for accurate DMT decisions.

The new process will (1) rapidly evaluate the training capability of proposed DMT federation players; (2) determine impacts of new or modified players on the performance of current federation members and the overall training system federation; (3) forecast whether specific mission tasks can be trained in current, proposed, and enhanced system configurations (4) enable detailed technical analysis data to be converted to mission task impacts understood by higher level decision-makers.

PHASE I: Develop methodology, establish metrics required for a demonstration database and provide a prototype TSRA relational database tailored to DMT. Provide a Phase I report on the methodology and operation of the database. Demonstrate the database using the F-15 WST federate integration as an example.

PHASE II: Update parametric and performance requirements for the database, including pre-programmed queries. Complete the database for existing entities such as the F-15, F-16, or AWACS to establish a baseline for future additions. Cover all interactions appropriate to DMT. Apply an addition to the DMT scenario, such as A-10 to help establish entity representational requirements and effects on existing entities.

PHASE III DUAL USE APPLICATIONS: Process and database will be expanded to cover all aspect of TSRA for any aircraft missions as well as into commercial applications supporting the Federal Aviation Administration (FAA) by providing a tool to optimize simulator hardware requirements to better meet training needs. Expand into civilian applications such as commercial and private vehicle operator training requirements for ships, trains, trucks and automobiles.. The databases and their processes could then be productized and sold commercially.

REFERENCES:

1. Department of the Air Force (1997). Distributed Mission Training Operational Requirements Document (CAF [USAF] 009-93-I-A). Washington, D.C.

2. AFHDBK 36-2235, Information for Designers of Instructional Systems -Vol 3 Application to Acquisition, (Chapter 5) (1993). Washington, D.C.: Hq United States Air Force.

KEYWORDS: Distributed Mission Training (DMT), Training Systems Requirements Analysis (TSRA), Mission-Oriented Training and Metrics, Air Force Task List, Measures of Effectiveness (MOEs) or Performance (MOPs).

AF02-069 TITLE: Aircrew Bladder Relief Capability

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop and demonstrate a novel bladder relief capability for both male and female aircrew members flying in aircraft that have no toilet facilities. The proposed solution must significantly improve the capability of all aircrew members to obtain relief on long-duration missions without adverse side effects.

DESCRIPTION: Present bladder relief capability for male aircrew consists of a plastic tubing and bag assembly that depends on gravity to collect the urine. Females use commercially available adult diapers. Both of these solutions have serious drawbacks. Male F-16 aircrew often put the aircraft into a dive to ensure that urine does not leak onto their clothing. Additionally, they have to partially undress in order to use the device. High-g maneuvers assure that females will have wet clothing. The new solution must resolve the problems of leakage and adverse aircraft orientation for use and also address the issues of fit and comfort. The proposed solution should be a full-dress solution (in other words, it should provide hands-free operation). The proposed device should be easy to don, comfortable to wear and remove, and fit so that leakage is eliminated. It should also be compatible with current aircrew protective ensembles, such as the Advanced Technology Anti-G Suit (ATAGS). The design should use as much commonality as possible between the male and female systems. A single device is preferable but proposals for seperate devices will be considered.

PHASE I: Laboratory demonstrations will be conducted to indicate the feasibility of the method proposed to improve bladder relief capability. Specifically, the new approach shall focus on designs for the male and female systems and materials that demonstrate acceptable levels of comfort. It should also address issues of capacity (enough to handle current long duration missions for fighter aircraft), flow rates and other performance factors.

PHASE II: Provide prototype systems for both male and female and test those systems under various flight conditions. Tests shall address comfort of wear and removal, ease of installation, leakage prevention, and performance issues such as flow rate and capacity. Different materials and designs may be tested to determine which provides the best solution. A final prototype and technical documentation will be delivered.

PHASE III DUAL USE APPLICATIONS: Phase III military applications include use by both male and female aircrew especially on long duration missions. Phase III commercial applications include medical applications for non-ambulatory patients. Commercial applications could also include replacement of diapers for incontinent adults.

REFERENCES:
Operational Requirements Document (ORD) CAF(USN 033-94)-I-A for a Female Aircrew Member Bladder Relief Capability, Air Combat Command

KEYWORDS: life support, bladder relief, urine, aircrew comfort, long duration flights

AF02-070 TITLE: Time Critical Targeting Cell (TCTC) for Team Training and Evaluation

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Design and develop a synthetic team task environment representing a Time Critical Targeting Cell (TCTC) for training and evaluation of command and control strategies and operations.

DESCRIPTION: Due to the nature of military operations, training systems are required to produce command and control (C2) personnel who are error free in perceiving and comprehending the battle theater as well as capable of coordinating a plethora of time critical missions of the Air Force. The Warfighter Training Research Division of the Air Force Research Laboratory (AFRL/HEAI) conducted a front-end analysis of C2 operations centers. The analysis found that the fast tempo of military operations, high turnover rates of operators and trainers, and technological advances in C2 systems place an enormous significance on teamwork. Trainers and trainees are frequently not fully prepared for their tasks and trainees are not certain how their task fits into the overall goals of the team. In addition trainees are not sure how information must be communicated and coordinated with other teammates, and there is limited opportunity to train and conduct training and certification activities in concert with other members of the Air Force. Based on the requirements of the Aerospace Command and Control Intelligence Surveillance and Reconnaissance Center (AC2ISRC), training needs to involve a convenient, realistic, team-based C2 environment in which operators practice C2 operations and develop team coordination, communication, and cohesion. Distributed mission training has begun to address these issues for the airframe community and can now look to address these issues for the C2 community. The domain represented by the synthetic team task environment would be flexible to accommodate a variety of team tasks, though the initial domain would represent the generic operations of a TCTC. The environment would be distributed over the internet or local area network, accommodate large teams, and permit collection and evaluation of team communication and coordination data. The environment would include automated or intelligent entities representing targets and teammates, yet permit these entities to be operated by humans via network connectivity. Design and development will be in accordance with the Advanced Distributed Learning (ADL) initiative, launched by the Department of Defense (DOD) and White House Office of Science and Technology Policy (OSTP) in Nov 97.

PHASE I: Identify critical teamwork skills and develop design specifications for a synthetic team task environment for training and evaluation of team functionality within the context of a Time Critical Targeting Cell.

PHASE II: Design and develop a prototype of a synthetic team task environment for training and evaluation of teamwork communication and coordination of C2 strategies and operations in a TCTC.

PHASE III DUAL USE APPLICATIONS: Although the prototype targets the TCTC, synthetic task environment should be flexible enough to permit training and evaluation of teamwork skills in a variety of military and nonmilitary domains. Possible nonmilitary domains include commercial air traffic control, emergency dispatch, and disaster relief operations.

REFERENCES:
1. Advanced Distributed Learning Initiative, http://www.adlnet.org/

2. Defense Information Infrastructure (DII) Common Operating Environment (COE) Integration and Runtime.

3. Specification (I&RTS) Version 3.0 (Draft), January 1997, Joint Interoperability and Engineering Organization, Defense Information Systems Agency.

KEYWORDS: Distributed training, Time Critical Tareting Cell, TCTC, Command and Control, C2, Advanced Distributed Learning (ADL), Synthetic Training Environments, Team Training

AF02-071 TITLE: Distributed Interactive Training for the C2 Aerospace Operations Center (AOC)

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Design and develop interactive training tools to facilitate a working knowledge of the information processes and procedures associated with the Aerospace Operations Center (AOC).

DESCRIPTION: The AOC is the weapon system (personnel, capabilities and equipment) through which the Joint Forces Component Commander (JFACC) exercises command and control of aerospace forces. It provides the control capability enabling the JFACC to decisively command these forces. The AOC, as the senior element of the Theater Air Control System (TACS), enables the JFACC to exercise the art of command and the science of control to make effects based decisions. The mission of the AOC is to plan, execute, and assess aerospace operations. Each of these functions is performed through the integration of numerous aerospace disciplines and specialties in both a vertical and horizontal fashion. Horizontal integration is the seamless linkage of lateral elements, to optimize personnel, functional and support systems capabilities. The AOCs horizontally integrated functions funnel developed options vertically to the decision maker to flexibly respond to a dynamic battlespace environment. Vertical integration is the seamless linkage of superior and subordinate elements within the TACS, joint force, and external agencies to optimize personnel, functional, and support system capabilities. The Air Force Command and Control Training and Innovation Group (AF C2TIG) is the primary organization tasked to provide a standardized training program for AOC personnel at the operational level. At present, the training provides a broad overview of the AOC in terms of its organization and structure. The need exists, however, for training that addresses the horizontal/vertical processes or flow of information through the AOC. Such training would provide the user a cognitive framework for assessing the importance and relevance of the information flow to the overall processes that occur within the AOC. In addition to process flow training, students must learn how to use the application in a context they will need to apply them in the AOC. The training system will be implemented via an internet/intranet environment allowing ease of access to any and all students, whenever and wherever needed. Training design and development will be in accordance with the Advanced Distributed Learning (ADL) initiative, launched by the DoD and White House Office of Science and Technology Policy (OSTP) in Nov 97.

PHASE I: This phase will focus on demonstrating the feasibility of designing and developing an interactive scenario-based process training system to address the horizontal and vertical processes or flow of information through the AOC. Define/design (a) cognitive models or framework to depict horizontal/vertical integrated functions within and throughout the AOC; (b) instructional strategies to teach the integrated functions; and (c) preliminary system architectural specifications. Develop technical report documenting Phase I effort.

PHASE II: Design and develop a functional and operationally evaluated training prototype to demonstrate the horizontal/vertical flow of information through the AOC, with the objective to produce fully functional product to commercialize in Phase III. The system will be implemented via an internet/intranet environment allowing ease of access.

PHASE III DUAL USE APPLICATIONS: This technology will benefit current/future military and civilian programs requiring a cognitive framework for assessing the importance and relevance of information flow. Examples include the Joint Battlespace Infosphere, the Global Information Grid, and other military and commercial communications and information systems, where an enhanced understanding will lead to increased operational effectiveness and efficiency.

REFERENCES:
1. AFI 13-109, Vol. 3. Aerospace Operations Center Operational Procedures, Jun 1998.

2. Advanced Distributed Learning Initiative, http://www.adlnet.org/

3. Defense Information Infrastructure (DII) Common Operating Environment (COE) Integration and Runtime Specification (I&RTS) Version 3.0 (Draft), January 1997, Joint Interoperability and Engineering Organization, Defense Information Systems Agency

KEYWORDS: Distributed training, Aerospace Operations Center (AOC), Command and Control (C2), Aerospace Forces, Advanced Distributed Learning (ADL), interactive training systems

AF02-072 TITLE: Integrated Satellite Operations Training and Rehearsal for Multiple Satellite System Ground Control

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop a high-fidelity integrated operator training and rehearsal environment for multiple satellite system ground control.

DESCRIPTION: There is a significant need for the development of an integrated simulation-based operator training and rehearsal capability for multiple satellite system ground control. Satellite systems have traditionally consisted of a master control system for one primary satellite constellation performing a specific mission. However, future generations of military satellites should logically use a common ground system which will operate several disparate satellite constellations within a mission area (e.g., MILSATCOM CCS-C which is under development now; MILSTAR legacy system, Advanced EHF (AEHF), and WGS systems along with DSCS). Given the breadth of the proposed systems such a common system could host, there is a substantial payoff in conducting the research necessary to support a common training and rehearsal capability for next generation satellite operations. Moreover, at the present time, there is no common or integrated training, rehearsal or operational architecture that would permit multiple space systems operation and control. The diversity of space systems and the lack of a common control station architecture severely limits the capability of the space community develop mission-ready operators in a timely fashion. As personnel move from one operational system to another, the differences in user interfaces and the underlying functional capabilities of the different systems precludes training and operational transfer of knowledge and skill from one system to the next. This effort will conduct research to define and represent common and unique mission and user requirements across multiple satellite systems, will develop and evaluate alternative approaches to information display and management and will explore innovative approaches for the development of a common architecture and exemplar for training and rehearsal. The exemplar would permit a single operator to be able to operate different satellite systems with minimal spin-up or retraining as they move from system to system. The developed environment can serve as the baseline architecture for both upgrades to current operational systems and to the design of operator and training consoles for future systems.

PHASE I: Phase I activities will result in proof-of-concept methods for defining and representing common and unique critical satellite operator knowledge and skill requirements across two current operational satellite systems. Phase I will also assess the feasibility of matching knowledge and skill representations with alternative training and rehearsal principles of learning and delivery methods and will develop specifications for a prototype integrated common architecture for cross-platform training and rehearsal for a multiple satellite system ground control capability.

PHASE II: Phase II activities will result in a proof-of-concept of the methods for defining and representing common and unique critical satellite operator knowledge and skill requirements across the systems identified in Phase I. Phase II will also demonstrate a capability for matching knowledge and skill representations with alternative training and rehearsal principles of learning and delivery methods and will develop and demonstrate the prototype integrated common architecture exemplar for cross-platform training and rehearsal for a multiple satellite system ground control capability.

PHASE III DUAL USE APPLICATIONS: This effort will provide an innovative toolset and technology for defining and representing satellite operator knowledge. Knowledge representation is typically a time consuming process that yields substantial data for use in training design and delivery as well as performance evaluation. The value of such a toolset is significant given that it will permit the rapid specification of common and unique operator competencies that will drive a streamlined training and rehearsal development process. As the number of disparate satellite constellations continues to grow, the need for a common, tailorable, high-fidelity and instructionally valid training and rehearsal simulation architecture will increase significantly. Considerable public and private sector savings will be realized if common training, rehearsal and operational architectures are fielded. Finally, mission readiness rates can be dramatically increased using common approaches while on-the-job error rates – which could result in the loss of satellite functions or the entire vehicle - and operational downtime – which typically means revenue for a private company – can be reduced significantly.

REFERENCES:

1. Cannon-Bowers, J.A., & Salas, E. "Making decisions under stress: Implication for individual and team training" Washington, D.C., American Psychological Association, 1998.

2. Merrill, M.D., Component Display theory. In C.M. Reigeluth (Ed.), Instructional design theories and models: An Overview of their current status. Hillsdale, N.J: Lawrence Erlbaum Associates, 1983.

3. Savery, J.R.& Duffy, T.M., "Problem-based learning: An instructional model and its constructivist framework," Educational technology, September/October, P 31-38, 1995.

4. Tambe, M. & Rosenbloom, P.S., "Agent tracking in real time dynamic environments : A summary and results. In M. Woodridge, K. Fischer. P. Gmytrasiewicz, N. Jennings, J.P. Muller, & M. Tambe (Eds.), Working notes of the IJCAI-95 workshop in agent theories, architectures, and languages (pp.173-189), 1995, Montreal, Canada.

5. Wellens, A.R., Group situational awareness and distributed decision making: from military to civilian applications. In N.J. Castellan, Jr. (Ed.), Individual and Group decision making, 1993.

KEYWORDS: Competency-based training and rehearsal, Human performance, Knowledge representation, Modeling and simulation, Satellite operation and control, Training effectiveness evaluation

AF02-073 TITLE: Advanced Runway Lighting Technology for Portable Applications

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop efficient and reliable temporary runway lighting systems to improve the ability of pilots and vision augmentation systems installed in aircraft. The goal is to land aircraft more safely at secondary landing sites with atmospheric attenuation from man made smoke, clouds, and rain.

DESCRIPTION: The need exists to evaluate developmental technology efforts in lighting components and their potential contribution to the portable lighting system mission. Developing new measures of effectiveness and evaluating the application of these technologies to new efficient and reliable system design while considering the operator and maintainer human element may also be necessary. We must identify and quantify the potential improvements offered by radical, advanced lighting systems from emerging laboratory technologies. The objective of this applied research is to obtain a safe, reliable and efficient runway lighting system concept that is portable and suitable for operation at austere or unimproved airfields.

PHASE I: Effort in this phase will concentrate on defining the proposed concept, outlining the basic principles and technologies, and determining potential solution candidates. In addition, an example of the advanced performance that will result from the technology will be presented and quantified by analysis. This analysis will also determine potential risks and document the extent of the improvement over current, conventional methods. A proposal for the next phase of development of the selected concept will be provided.

PHASE II: This phase will concentrate on selecting a single lighting concept and developing a portable runway lighting system based on the selected concept. A prototype system will be assembled to demonstrate the advanced technology under actual operational conditions, including flight operations. Emphasis should be placed on developing hardware that is: easy to transport and deploy, safe, reliable, lightweight, energy efficient, and self supporting. A conceptual analysis of the life cycle cost improvements resulting from using emerging technologies should also be prepared.

PHASE III DUAL USE APPLICATIONS: The application of new technologies to improve portable runway lighting systems would benefit multiple military services. Conventional portable systems use the same technologies from those in use 40 years ago. The highest commercial payoffs could result from wider adoption by national and international civil runway lighting systems and emerging augmentation systems. Companies in the United States, Canada, Germany, Sweden, France and others have been recently active marketing interim conventional portable runway lighting systems.

REFERENCES:
1. Kavioja, D.A., Comparison of the Control Anticipation Parameter and the Bandwidth Criterion During the Landing Task (Anticipation Parameter and the Bandwidth Criterion During the Landing Task) http://www.au.af.mil/au/database/research/ay1996/afit/gae-eny-96m-02.htm

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4. Katz, E.S., Visual Guidance requirements for GPS Approaches. DOT/FAA/CT-TN94/40, Atlantic City, NJ., FAA Technical Center, Jan 95, AD-A290951.

5. Kovalev, V.A., "Improvement of the procedure for calculating runway visibility," Journal of Soviet Meterology and Hydrology, vol. 10, pp. 23-28, 1990

KEYWORDS: Aircraft Landings, Airports, Lighting Technology, Optics, PLS (Precision Landing System), ILS (Instrument Landing System), JPALS (Joint Precision Approach and Landing System), All Weather Aviation, Terminal flight facilities, fronts (Metrology), FAA Integrated Terminal Weather System (ITWS), Parametric Analysis and optimization, Emergency Airfield Lighting, Lighting Technology, Light Emitting Diode (LED) technology, high reliability LED array technology.

AF02-078 TITLE: Messaging Interaction Simulation

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop an intelligent simulation training environment to support the instructor and student interaction of a subscriber terminal.

DESCRIPTION: Advances in the understanding and application of student and instructor interaction has made rapid progress due to the technological changes in education and training. However, these advances have not been applied to the majority of space system training and education, nor have these advances been explored for potential application to space training. Currently, there is a desperate need for innovative applications from research to apply to space programs that would facilitate the student and instructor interaction of subscriber terminals without intervention into the operational environment. A simulation capability is needed to replicate the operational unit messaging system. The need for training is apparent in the deficiency of operator capability to interpret data and send an operational status message to all within the network. The intelligent simulation approach should allow space operators a high fidelity, mission-oriented training capability to enable instructor and students to communicate via terminals through an unclassified path on the current subscriber terminal. In addition, the tool should allow the user to send a scenario of low speed data and send and receive plain text messages. This capability should enhance student abilities to understand the operational messaging system through simulation training and develop efficient and accurate instant message capabilities for information dispersion to an individual with specific need or for all participants within a space network. An ultimate proof-of-concept simulation technology capability will be developed based on demonstration assessment.

PHASE I: Demonstrate the feasibility to develop an application simulation training technology to support the instructor and student interaction and messaging required for an operation check list. Training technology demonstration and CONOPS assessment should be used to support the training capability.

PHASE II: Develop and demonstrate a prototype messaging simulation technology to support and assist the training of students using a subscriber terminal to increase the efficiency and effectiveness of operational performance. The training efficiency and effectiveness of this technology to the training environment will be documented to support ongoing USAF systems and potential commercial/dual-use platforms.

PHASE III DUAL USE APPLICATIONS: Successful Phase III Dual-Use Commercialization will result in transition of the messaging system simulation training technology to specific noted areas assessed by space as deficient in training and to assist current USAF space and satellite systems. At least one dual-use/commercial application of this technology will allow advancement in communication and simulation technology. This technology could also provide applications in the private sector and other government agencies to assist in maintaining operational effectiveness.

REFERENCES:
1. AFMC Training Systems Product Group Distributed Mission Training Home page: http://tspg.wpafb.af.mil/programs/dmt/default.htm

2. SBIRS rds: Program Home page: http://www.laafb.af.mil

3. Chairman, Joint Chiefs of Staff, Joint Vision 2010. (1997).

KEYWORDS: Subscriber terminal, Instant messaging system, Student/Instructor interaction, Satellites systems, Satellite operations, Simulation modeling, Space Based Infrared System

AF02-080 TITLE: Imagery Manipulation for Simulator Databases

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop tools to automatically remove objectionable time-specific artifacts from overhead imagery and to automatically create 3D cultural features from overhead source imagery usable for simulator database development.

DESCRIPTION: This program will investigate technologies and develop a tool to, starting with overhead imagery usable as source data for simulator database development and modification, automatically recognize objectionable time-specific artifacts within the imagery, automatically remove these artifacts and replace them with appropriate nontime-specific data, and automatically generate accurate 3D cultural models based on the resulting modified imagery. Numerous numbers and types of image data covering simulated areas will be merged, ortho-rectified, and tone/color balanced. Objectionable time-specific imagery artifacts, such as aircraft parked on airport tarmacs, automobiles parked in parking lots, and all cast shadows will be automatically recognized, deleted from the image data, and replaced with appropriate and believable information. This tool should allow for programmable options for how many and what types of artifacts should be considered, allowing for cases when it will be desirable for certain artifacts to be retained as they were collected in the source image. Various 3D cultural items of potential value to later realtime simulations will be "tagged." Once the image data is cleared, "treated," of objectionable artifacts, 3D cultural models of previously identified and tagged items (such as buildings, clumps of trees, individual trees, etc.) will then be program-selectively automatically generated directly above their location on the treated image. Height of the 3D models will be accurate based on information attainable from the image(s). All vertical sides of the resulting 3D models will be filled in with realistic data and saved in OpenFlight (.flt) format. This technology will not be imagery format/media dependent or limited by camera/image collection hardware type, accounting for black-and white or natural color imagery, various bands of infrared, synthetic aperture radar, etc. Resulting treated imagery will be saved in Tagged Imagery File (.tif) format and in National Imagery Transmission Format, version 2.1 (NITF 2.1). Resulting 3D models will have accompanying information correctly positioned on the resulting merged, orthorectified and balanced, and treated imagery. Automation of this capability will be maximized.

PHASE I: Investigate the technical feasibility to design a tool to perform the following: merge and orthorectify various numbers and types of images, automatically recognize objectionable time-specific image attributes and items of potential value to later simulations, and remove program tool selectable attributes and replace them with realistic and believable non-time-specific data. Develop a preliminary capability to generate 3D OpenFlight models of selectable items identified in the imagery and position them properly. Document the results at the "draft" level. Deliver source code for the tools as developed at this level of completion.

PHASE II: Continue investigations and refine Phase I capabilities as necessary to develop an advanced capability automated tool and demonstrate the result using a variety of combinations of source imagery data. Document the results. Deliver a "draft" users' manual in both hard copy and soft copy (Word document). Deliver documented source code for the prototype tool.

PHASE III DUAL USE APPLICATIONS: This tool will benefit current and future military and civilian commercial programs that require extensive use imagery based simulator databases with a high degree of specific 3D cultural content. Results will provide a higher fidelity product with reduced resources.

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1. Crane, P.M. (1985). Flight training simulators: Effects of terrainaccuracy on simulated radar image quality (AFHRL-TP-85-28, AD A160905).Mesa AZ: Air Force Research Laboratory, Warfighter Training Research Division.

2. Pierce, B.J., Geri, G.A., & Hitt III, J.M. (1998). Display collimationand the perceived size of flight simulator imagery (AFRL-HE-AZ-TR-1998-0058,AD A359409). Mesa AZ: Air Force Research Laboratory, Warfighter Training Research Division.

KEYWORDS: Data imagery, database models, databases, imagery-based simulator databases, realtime simulation, simulator databases, simulators

AF02-081 TITLE: Advanced 50 dB Hearing Protective/Voice Communication System for 150 dB Noise

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop innovative technology to protect hearing of personnel working in noise fields up to 150 dB sound pressure level by providing 50 dB of noise attenuation while providing communication capability.

DESCRIPTION: Combined passive and/or active attenuation technologies configured as insert, semi-insert, and/or circumaural devices. The hearing protection system should be capable of providing 50 dB of attenuation in a 150 dB noise field for a wide range of users at an affordable cost. In order to improve speech communication adaptive algorithms/digital signal processing of the incoming speech signal may be considered. Additionally miniature on-board power sources may be considered for complete in the ear function.

PHASE I: System design study including feasibility analysis, cost/performance trade-off analysis, and an transducer evaluation for operation in the defined noise fields.

PHASE II: Working advanced hearing protection/voice communication system for providing 50 dB attenuation in 150 dB noise environment including drawings, hardware, software, performance charts, manufacturing feasibility, projected reliability, estimated procurement costs, and estimated total life cycle costs.

PHASE III DUAL USE APPLICATIONS: Hearing loss and poor voice communication difficulties are generic to high noise activities worldwide. This technology has immediate commercial application to civilian industrial sectors including airline industry, firefighters, law enforcement, search and rescue, industrial high pressure paint removal, mining, and other high noise industrial settings.

REFERENCES:
1. DoD Design Criteria Std., Mil Std. 1474D, Noise Limits, 12 Feb97, page 65, par 4.2.1, Aircraft Noise.

2. DoD Instruction 6055.12, Hearing Conservation Program.

3. AFOSH Std. 48-19, Hazardous Noise Program.

4. AFOSH Std 161-20, Hearing Conservation Program.

5. OSHA 29 CFR, Occupational Noise Exposure.

KEYWORDS: Hearing Protection, Voice Communication, Hazardous Noise, Active Noise Reduction, Hearing Conservation

AF02-082 TITLE: Viewer for Vision Research in Developing Agile Laser Eye Protection

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop a viewer to enable research on effects of "agile" laser eye protection (LEP) devices on human vision.

DESCRIPTION: Concepts for military applications of lasers are increasing exponentially. Applications range from eye-safe, relatively lower power systems to be employed as non-lethal devices (NLD) in military operations other than war (MOOTW), to giant megawatt-class airborne/space borne systems capable of destroying ballistic missiles in flight. Protecting the vision of military personnel from lasers is essential to successfully accomplishing future missions. Because of the wide range of laser powers, emission wavelengths, emission durations (pulse widths) and repetition rates, coupled with the variable mechanisms of resulting biological effects, a "single" laser eye protection (LEP) solution remains elusive. Technologies providing "fixed" wavelength filter-type devices (dye, dielectric stack, rugate, and hologram) are effective at providing protection, but as one increases the number of blocked wavelengths in the visible spectrum there is a corresponding decrease in visual performance. This becomes a particular problem for night operations, creates color confusion, and eventually becomes unacceptable even for daytime use as the number of blocked wavelengths increases. At this time a potential solution to this problem is a look-through device capable of protecting against a large number of wavelengths, activating only when illuminated, and protecting only against the wavelength(s) of illumination with just enough optical density (OD) to produce the necessary protection (an "agile" device). Although we have some knowledge of visual penalties incurred with fixed filters, we have only some educated guesses regarding vision performance impacts associated with current technology candidates for "agile"

devices, i.e., photochromic materials, liquid crystals (continuous laser emissions) and optical limiters (pulsed laser emissions). For example, what might we expect in terms of reduced resolution, contrast sensitivity, color discrimination and field of view? Is it possible to correct for color distortion in active devices while protecting vision? If necessary, how might one accommodate a requirement for correction of visual refractive errors in active devices? Other questions of interest include: how well will people adjust to wearing agile devices, and how often will these devices cause side effects like eye strain, headaches, nausea, and/or spatial disorientation? Research is needed to answer these questions but we currently have no way to simulate optical properties of an agile device in order to accomplish this research. Therefore, we require a "look-through viewer" that produces images of quality and content consistent with those of prospective photochromic-, liquid crystal- and/or optical limiter-based LEP, and is capable of generating the equivalent of 4 OD of protection at each of two wavelengths separated by at least 100nm in the visible spectrum (simultaneously) and each of two wavelengths separated by at least 100nm in the near infrared spectrum (simultaneously) alone or in combination with either or both of the protected visible lines.

PHASE I: Perform a technology feasibility assessment and deliver, if determined to be feasible, a description of the conceptual solution and a technology/technologies development proposal.

PHASE II: Execute the technology development plan proposed in Phase I and demonstrate the solution by delivering a prototype viewer.

PHASE III DUAL USE APPLICATIONS: This is likely to be a complex and expensive piece of equipment. Therefore, the overall market for the product is likely to be military, university, and commercial research laboratories interested in studying neurophysiological mechanisms of human visual perception and cognition. The number of these stand-alone products sold on the open market is likely to be in the "tens" rather than the "thousands." However, this work directly supports the "Joint Technology Office High Energy Laser Master Plan" initiative to cultivate directed energy-relevant technological capabilities in the private sector. The "universe" of companies with credible capabilities in the design and fabrication of these component technologies is very small. The knowledge and experience gained in performing this work (maturing and assembling the component technologies) will cultivate additional capabilities to address high priority, upcoming requirements for design, development, and fabrication of agile LEP. It is also well within the realm of possibility that these component technologies will find spin-off applications, such as miniature displays (for military aviators and ground troops), ultra-fast shutters for spectroscopy applications. If, 20 years from now, people are still flying airplanes we may be able to make aircraft canopies and windscreens, military and private/commercial, out of this "stuff."

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KEYWORDS: Laser eye protection, Agile devices, Liquid crystals, Photochromic materials, Optical limiters, Visual performance

AF02-083 TITLE: Fatigue Assessment through Voice Analysis

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop a voice analysis system to assess a speaker's fatigue state.

DESCRIPTION: There continues to be a need for a non-obtrusive fatigue assessment system. One of the least intrusive methods, both in the laboratory and in the field, is voice analysis. Voice analysis has been used in accident investigations to examine whether a pilot may have been hypoxic(ref 1) or a ship captain intoxicated by alcohol prior(ref 2) to an incident. Voice measurement may also be useful in information operations, alerting observers to

high-fatigue states in their opponents. Finally, such a Fatigue Assessment through Voice Analysis System would be useful in the laboratory to assess an individual's fatigue state without the need for obtrusive experimental equipment.

Voice has been shown to be sensitive to fatigue(ref 3). However, there are many issues concerning voice, which have received little or no scientific attention. Some of these are: comparing fatigue to alcohol, refining voice analysis techniques for fatigue, and packaging a voice system to be easily operated and understood. Producing a complete state assessment (i.e. fatigue, workload, intoxication) into a single system would produce a very useful tool. The system's utility would be further enhanced if it were constructed in Java such that the tool could be moved to whatever system contained or was to record the voice data.

PHASE I: Demonstrate the feasibility of using voice analysis as a fatigue assessment tool. Review extant algorithms and methods as potential candidates for voice analysis. Define the system architecture for Phase II development. Phase I efforts should be focused on English speakers.

PHASE II: Conduct research to refine and/or generate voice analysis methods and tools. If not already in the literature, conduct short studies using voice analysis to differentiate fatigue from other parameters that affect speech. Develop and test an operationally-relevant prototype Fatigue Assessment through Voice Analysis System. Evaluate system effectiveness in assessing fatigue state in non-English speaking populations and identify enhancements required for effective performance in these populations.

PHASE III DUAL USE APPLICATIONS: Should the system prove viable, multiple applications within and without the USAF are anticipated. The system would be useful to a range of human performance laboratories, as well as, accident investigation organizations (i.e. USAF/FSC, NTSB, FAA). The system may also have both defensive and offensive applications for information operations.

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2. M. Brenner and J. R. Cash (1991), Speech analysis as an index of alcohol intoxication-The Exxon Valdez Accident. Aviation, Space, and Environmental Medicine, 62, 893-898.

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KEYWORDS: Fatigue, Voice Analysis, Human Capability Assessment

AF02-084 TITLE: Robotic cRNA Processing System for Gene Microarray Analysis

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop a robotics system to fully automate the process of preparing the cRNA target for hybridization with Affymetrix gene chips from total RNA samples obtained from biological material. The proposed system must include quality assurance activities at various steps in the process.

DESCRIPTION: The US Air Force is a high technology military force. To maintain leadership in military technology, the Air Force conducts research and development on a wide range of technologies and processes with the aim of fielding advanced weapons systems. These weapon systems utilize a diverse spectrum of exotic chemicals and materials to gain battlefield superiority. The health hazards of these materials must be evaluated to assure safe operations and to minimize life cycle costs for the weapon systems. The Air Force Research Laboratory has acquired the Affymetrix GeneChip oligonucliotide microarray system which allows for the detection of the expression of thousands of genes simultaneously. This new technology will improve our capability to identify the mechanism of action of chemicals of concern to the Air Force. Genomic studies of chemical toxicity will tremendously enhance available methodologies for risk assessment and improve capabilities for predicting the potential health risks to humans resulting from exposure to operational chemicals. However, extraction and processing of RNA samples into cRNA is a time-consuming, tedious, slow process and is the rate limiting step in generating gene expression profile data. The tools sought under this request should utilize the latest technologies to develop a robotics system to prepare cRNA targets. Such tools do not currently exist and successful development of the requested system will require research into compatibility of the sequence of biochemical reactions involved in sample processing. The system should be capable of extracting total RNA from biological materials and process the sample through various steps (cDNA synthesis, in vitro expression and cRNA labeling, and fragmentation of cRNA) required before the target is ready for hybridization with gene chips. The process involves numerous washings as well as quantitation of various physical parameters for

quality assurance. The robotics system should allow large-scale sample processing (i.e., 96 well-plate platform) and should include quality control and process check points at each critical stage. Considerations should also be given to such factors as reliability, reproducibility and consistency. The robotics system should take advantage of currently available technologies and should be automatic or semi-automatic with minimal human attendance required. Cross contamination of samples must be avoided. This topic requires the development of a robotics system that must carry out specific chemical reactions, molecular biology reactions and quality control processes that are not currently available commercially. This system will be used to automate the preparation of field samples from DOD personnel to evaluate their responses to chemical exposure at the genomic level. The robotics system would also be employed in the integrated toxicity assessment system that will be used to evaluate toxicity of emerging dangerous substances to which the warfighters will be exposed.

PHASE I: Demonstrate feasibility of a robotics system that implements RNA extraction and cDNA synthesis to demonstrate feasibility of the methodology for automantion.

PHASE II: Develop a prototype robotics system that implements RNA extraction and cDNA synthesis to demonstrate feasibility of the methodology for automantion.

PHASE III DUAL USE APPLICATIONS: This phase will result in an final integrated reliable robotics system that allow large-scale sample processing (96-well plate platform) from RNA extraction to cRNA fragmentation. With the first draft of human genome sequence completed and rodent and other species genome sequencing under way, an unprecedented era of biomedical research has arrived. The post-genomic era demands more powerful high-throughput automatic robotics system to process large numbers of biological samples. The robotics system sought by this SBIR will be utilized by various entities across industrial, academia and government research institutes. The robotics system will be licensed to a vendor and marketed commercially when completed.

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KEYWORDS: Human Effectiveness, Toxicology, Health Risks, Chemical Hazards, DNA microarray, Gene chip, Genomics, Toxicogenomics, High throughput, Automation, Robotics

AF02-085 TITLE: Adaptive Training for Real-Time Intelligence Monitoring & Evaluation

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: To develop a high fidelity positional training and rehearsal exemplar for information warfighters.

DESCRIPTION: Recent advances in text and voice recognition and in the use of interactive information exchanges such as the Internet provide the means whereby large amounts of information can be made available for theater operations and for decision making. Given the proliferation of information, a number of concerns must be addressed. These are related to the following: (a) identifying and gathering primary information; (b) monitoring information sources and quality, (c) assimilating information in ways so that it can be used efficiently and effectively; and (d) determining when the information being used has been corrupted or compromised. In addition the current OPTEMPO severely limits opportunities to adequately train and rehearse needed competencies for such a complex and dynamic environment. This effort will conduct exploratory research to develop an adaptive training and rehearsal capability for

operators who must monitor and evaluate incoming civilian and military information, identify key components of the information, identify inconsistencies in the information that would indicate data compromise, and provide near-real-time data to the human-in-the-loop for decisionmaking. It will also demonstrate the feasibility of subject-matter expert-based coaching to ensure that C4ISR personnel can use operational equipment at a mission ready level of performance in a much more timely fashion than is presently possible. A primary goal of this effort will be to explore the feasibility of using quantitative models found in voice and text recognition and latent semantic analysis to systematically evaluate and warehouse a variety of sources of information for use in strategic and tactical situations. It will incorporate an embedded adaptive coaching capability to identify shortfalls in current operator competencies and to tailor on-line training to ensure completion of mission-critical C4ISR tasks and activities.

PHASE I: Phase I activities will result in the development of preliminary adaptive interface and the quantitative intelligent information gathering, monitoring, and evaluation techniques. A proof-of-concept trainer will be developed and operator-tested.

PHASE II: Phase II will fully develop, apply, test, refine, and validate the technology. It will also complete development of the embedded adaptive coaching facility for both military and civilian applications. Proposals should assume that the technology will run in a platform independent environment.

PHASE III DUAL USE APPLICATIONS: This capability is of special interest to commercial companies that develop and manage large databases of information. For example, the proposed capability can be directly applied to literature data base search engines to increase their usability and accuracy. Applying this capability will not require wholesale rewrites of the existing databases or search capabilities, but would be used to augment existing search and retrieval capabilities and to add an information evaluation capacity that presently does not exist. There is also strong commercial potential for those companies that access such databases for their work. In this instance, the proposed capability will substantially enhance the utilization of information. Furthermore, there is considerable interest in the private sector for tools that enable managers to monitor the content and focus of discussion group and integrated product team conversations to identify when these groups have diverged from their main area of focus. It will be used to ensure that such teams are given feedback regarding their focus on the critical content areas and issues to be addressed. The developed technology will also provide an intelligent coach for new operators and information users to obtain and use more accurate information from a variety of sources.

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KEYWORDS: Adaptive training, Information operations, Intelligent information assessment, Latent semantic analysis,Voice recognition

AF02-089 TITLE: Enhanced Interoperability Through Common Translation Architecture

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop fully layered gateway translation architecture that ultimately provides seamless transfer of information across disparate data links

DESCRIPTION: The primary goal of this SBIR is to develop a new layered architectural approach for future translation gateways that enables data translation from one medium to another and/or among several mediums. With the mandated proliferation of Link-16 over the next 5 years, many aircraft System Program Offices (SPOs) are starting their Link-16 integration activities over the next 12-24 months, increasing the number of Link-16 systems in the inventory 10-fold. The System Integration Office (SIO) supports all of these SPOs by providing critical Link-16 system engineering/integration expertise. Every SPO must work together to ensure overall interoperability, not only among Link-16 participants but also among numerous other diverse systems and datalinks which are not Link-16 compatible. This non-interoperability with other diverse systems may be resolved by implementation of data forwarding rules, translation architecture(s), or other unique translation applications that act as a "Gateway" between non-communicative datalinks. These Gateways will provide communications connectivity for legacy and other disparate communications systems. Since legacy DoD systems will not be removed from the field at once, a translation requirement exists. This

translation requirement will remain, regardless of the future implementation of a global seamless communications infrastructure, until all systems use the future common infrastructure and a common information representation format. Accordingly, this SBIR seeks established or developmental initiatives that may exist in DoD or commercial practices that deal with the translation of data from one medium to another. As this SBIR progresses through its phases, the end objective will be to minimize the duplication of effort at various AF agencies, establish a centralized translation protocol and provide a body of reusable tools that any future gateway might use.

PHASE I: Develop translation protocols with the intent of developing a layered, common, neutral data architecture that provides simple modification, certification, and reuse of the layered modules. The effort will compare the developed architecture and prototype to the Transmission Control Protocol/Internet Protocol layered model. Translation and forwarding rules will be documented and available to alternate developers for future refinement. The innovator will also clearly show that a gateway neutral data format approach provides economic maintenance and sustainment benefits.

PHASE II: Design, build, and optimize a Gateway system that provides a natural portal for simulation and training systems both for now and the future. Incorporate the translation protocol into a Gateway System. The Gateway system, with appropriate peripheral radios and other components, will be integrated on the Global Hawk Endurance or Predator Unmanned Aerial Vehicle (UAV) for evaluation during a future Expeditionary Force Exercise (EFX) demonstration.

PHASE III DUAL USE APPLICATIONS: The benefits of this common, neutral data format are evident in the number of locations that will acquire the battlespace picture. The modeling, simulation, and training communities will also be able to use this Gateway architecture as a direct conduit to the real Command, Control, Communications, Computers & Intelligence (C4I) systems. Research into the commercial sector has uncovered similar data translation issues. A "spin-on" approach to addressing the military's concerns is plausible. The Open Applications Group (OAG), a commercial organization, is tackling very similar translation and forwarding issues from the electronic commerce and business interoperability perspective. The OAG is a non-profit consortium focusing on best practices and process based Extensible Markup Language (XML) content for electronic business and application integration. Open Applications Group, Inc. is building an industry consensus based framework for business software application interoperability. They are using Object Oriented Design and metadata concepts to implement their architecture. We believe these technologies will enhance our future communications interoperability solutions as well.The Open Financial Exchange standard used by commercial markets provides another good example of one approach for data interoperability. The Open Financial Exchange standard, created by Microsoft, Intuit and CheckFree in early 1997, provides a unified specification for the electronic exchange of financial data between financial institutions, businesses and consumers via the Internet. Open Financial Exchange supports a wide range of financial activities including consumer and small business banking; consumer and small business bill payment; bill presentment and investments, including stocks, bonds and mutual funds. It is evolving as a de facto standard for this industry. Aspects of these existing commercial technologies could be potentially altered for insertion into the proposed Gateway layered architecture. Data translation issues occur outside the military environment. It is hoped that this SBIR proposal may encourage innovative solutions from the commercial sector that are not readily obvious in the DoD arena.

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KEYWORDS: Gateway, Data Link Infosphere, Communication Bottleneck, Translation, Forwarding, Fusing, Seamless Data Transfer, Communications Interoperability, Transparent, Extensible Markup Language, Metadata, Link-16

AF02-090 TITLE: Data Link Common Software for Multiple Link-16 Applications

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop Low Cost Integration (LCI) common software for multiple Link-16 interfaces on a single platform.

DESCRIPTION: Link-16 has been mandated for implementation on several platforms and is currently in use on a number of platforms. Previous unique implementations of Link-16 have resulted in problems with interoperability and high software support costs. To achieve overall Link-16 software cost reductions, the LCI effort plans to develop a single common Link-16 software implementation to be shared among platforms. The Airborne Warning and Control System (AWACS) Data Link Infrastructure (DLI) has been selected as the initial Low Cost Integration solution for the Air Force. A number of changes will be needed to make this product suitable for all Air Force platforms, especially those command and control platforms with multiple data link interfaces. The present DLI provides transmit and receive processing of data exchanged on a single Link-16 communications link. A number of platforms that will be using the LCI require forwarding from one Link-16 network to another Link-16 network. These links are typically used in different geographic areas, between different organizations, or must be conveyed by different transmission media. It is necessary to establish an accurate, reliable, straightforward approach to provide data link forwarding for such platforms. The forwarding scheme must maintain data integrity and must not degrade the accuracy of the data communicated. Forwarded data delay times (latencies) must be minimized to ensure continuing utility of the forwarded data. Duplicate track identities and data looping must be avoided. Reporting responsibility rules must be followed to ensure use of only the best available data.

PHASE I: Develop a Link-16 architecture with multiple interfaces within a single platform all operating Link-16 that provides a data forwarding capability between links to interconnect various Link-16 capable command and control platforms such as the Combat Reporting Center (CRC), the AWACS, Joint Stars, the Airborne Laser (ABL), the Modular Control Element (MCE), the Tactical Air Control Party (TACP) and others. Data forwarding capability will be from Link 16 to Link 11.

PHASE II: Build and test a sample implementation of the forwarding architecture, implementing the management and forwarding of messages between multiple links, LINK 16 AND LINK 11, e.g. ABL, AWACS, Joint Stars, MCE. Evaluate the performance and data latency as the number of data links increases. Determine the maximum number of links involved in data forwarding that can provide data integrity, acceptable data latency, and accuracy. Develop documentation to meet the performance requirements and interface definitions suitable for the platform, e.g. ABL, AWACS, Joint Stars, MCE.

PHASE III DUAL USE APPLICATIONS: Develop documentation to meet the performance requirements and interface definitions suitable for the platform, e.g. ABL, AWACS, Joint Stars, MCE. Demonstrate how the forwarding architecture approach can be applied to data transfer between multiple commerical wireless local area networks with low latency.

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[4] Link-16 MIL-STD-6016A and approved Interface Change Proposals. Documentation will be in draft format in October 2001 and final format in December 2001.

[5] Link 11 MIL-STD 6011 and approved Interface Change Proposals

KEYWORDS: Data Link Infrastructure, Data Link Forwarding, Common Data Link Software, Link-16, Low Cost Integration

AF02-091 TITLE: Innovative Method for Performance & Mission Worth Analysis of Integrated Command and Control Systems

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop information technologies to compute measures of performance for command and control and advanced information systems architecture.

DESCRIPTION: The network revolution has just begun: our desktop computers, cell phones, and personal digital assistants are networked, and in the future every home and office device will have a digital presence on the network. In the defense sector, the joint vision is for a network-centric battlefield, where all battlefield command and control nodes are on a network that is highly mobile and adaptive. These future commercial and defense information system architectures will allow people to interact with their environment and other people in rich and robust ways. But current methodologies for development of information systems are not up to the challenge of a highly networked, dynamically changing environment. In both the defense and commercial sectors, new methodologies are needed for designing, analyzing, and developing future information system architectures and measuring the performance of systems based on these architectures. In this research effort the contractor shall develop and demonstrate innovative information technologies to simulate and compute measures of performance for command and control, and other advanced information and communications system architectures. The contractor should consider employing technologies such as colored petri nets, unified modeling language, or similar approaches for specifying system architectures. The methodology shall include the ability for the user to specify the integrated operational/system architecture as an input. The contractor shall develop methodologies to compute mission and military worth, measures of performance, identify bottlenecks, and perform sensitivity analysis. The contractor should consider measures such as reachability, reversibility, absence of deadlocks, liveness, boundedness and mutual exclusion, and information system metrics such as latency, queue lengths, precision, evolvability, scalability, testability, formality, executability, tolerance, clarity, and cost effectiveness. Proposed methodologies must be capable of executing on commercial-off-the-shelf desktops or workstations and be platform independent. Any graphical depiction and output should comply with industry or international standards such as HTML, VRML, and graphics metafile images. Methodologies implementing the information system architecture should be open and standards based to support interfaces to other engineering and network simulation and modeling tools.

PHASE I: Phase I activity shall include: 1) specification of an information systems architecture modeling methodology to determine the performance of integrated operational and system architectures, 2) developing a design concept to compute measures of performance for command and control and information systems, and 3) a proof of concept demonstration.

PHASE II: The contractor shall accomplish a detailed design, develop, and demonstrate the system for command and control and advanced information systems applications. The contractor shall also detail the plan for Phase III effort.

PHASE III DUAL USE APPLICATIONS: The desired product of Phase III is a robust, off-the-shelf modeling and analysis system for use in defense and commercial automated information system development applications and discrete manufacturing applications.

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[3] Unified Modeling Language, http://www.rational.com/uml/index.jsp/

KEYWORDS: Performance Metrics, Command and Control, System Architecture, Integrated Architecture, Colored Petri Nets, Military Worth Analysis

AF02-092 TITLE: Portable Universal Ground Processing Unit

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop a portable universal ground processing unit (PUGPU) to control satellites in any frequency bands through a ground antenna.

DESCRIPTION: The architecture of a typical ground station of today for satellite control consists of three major groups of equipment: radio-frequency (RF), intermediate frequency (IF) and baseband, and the ground communications interface. The RF group includes the antenna and high power amplifiers for communicating with satellites. The RF group is usually large in size, especially if it is built for controlling high altitude satellites in frequency bands such as L and S bands. For higher frequency bands (such as super high frequency (SHF)) and lower satellite altitudes the RF group can be smaller. The IF and baseband equipment is amenable to size and weight reduction because of its large digital electronics contents. The IF and baseband equipment also tends to be applicable to multiple RF bands through properly selected IFs. The ground communications interface relays the Tracking, Telemetry and Control (TT&C) data between the remote ground station and the satellite control center (SOC). The current and future trend of the ground communication interface is to plug into the global wide area network (WAN).This research topic is to develop a portable universal ground processing unit (PUGPU) to perform the functions of the IF, baseband, and ground communications interface groups. An ideal PUGPU can be plugged into any RF group for communicating with satellites and into any local WAN service point for interface with a SOC. This ideal PUGPU will accommodate satellites in a universal way to include supporting multiple RF bands, multiple bandwidth-efficient waveforms and error correction coding capabilities used for current and future satellite control functions. It will also be compatible with industry standards and protocols so it can be easily plugged into the global WAN to easily communicate with a SOC. The RF groups to be supported by the PUGPU shall be selectable from a set of multiple bands to include at least L, S, X, and SHF bands. The waveforms supported by the PUGPU include those used for ranging, modulation and demodulation. The PUGPU shall provide a set of user selectable bandwidth efficient waveforms. The PUGPU shall provide forward error correction coding capabilities and accommodate the highest data rates for current and future satellites. The PUGPU shall support current and future industry standards and protocols for satellite and global WAN communications. Standards and protocols shall include SGLS used by DoD satellites, and those recommended by Consultative Committee for Space Data Systems (CCSDS). TCP/IP, ATM, and other potential protocols shall also be considered for the global WAN communications. Selection of common IFs is a key to isolate the different RF bands from influencing the baseband design. This research topic shall develop a set of common IFs to maximize the range of applicable RF bands for the PUGPU. In summary, a PUGPU will possess the following desirable features: - Small in size, weight, and power to be portable - Frequency-selectable transmit and receive modules - Waveform-selectable formatter and de-formatter - Coding-selectable encoder and decoder - Common IF frequencies - Ability to handle the highest anticipated data rate and power level - Selectable communications interfaces to global WAN

PHASE I: Examining both commercial off-the-shelf and specially designed hardware to determine the minimum weight, size and power of a Portable Universal Ground Processing Unit (PUGPU). The analysis must also estimate the cost of developing a prototype PUGPU, an operational demonstration unit and a normal production run. All these estimates should include the cost of developing special hardware. Any high-risk items must be identified. The proposed PUGPU includes the features mentioned above.

PHASE II: Fabricate and test an engineering prototype of the Phase I hardware and software. Compare the results to the performance objectives and discuss how modifications will allow meeting any failed objectives. If the operational unit requires specially designed hardware that the prototype did not use prove that the prototype design verifies the special hardware and reduces risk. Repeat the cost estimate for an operational demonstration unit and a normal production run but also include a savings estimate comparing the cost of purchasing and operating the PUGPU with the cost of purchasing and operating a current system with the same functional capabilities.

PHASE III DUAL USE APPLICATIONS: Numerous Air Force, NASA, NOAA and commercial satellite programs benefit from developing a PUGPU. Its reduced size, weight and power plus the elimination of numerous electronics racks reduces operation costs. Whether purchasing costs are reduced depends on the Phase II cost analysis. The PUGPU also permits a site to communicate with any satellite if that site has the appropriate antenna and associated equipment. This increases site flexibility. With the Phase II test results and cost estimates both government and commercial satellite programs can be contacted and funding from either one or both obtained to develop an operational PUGPU.

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KEYWORDS: Multiple Frequency Bands, Multiple Waveforms, Bandwidth Efficient, Error Correction Codes, Standards and Protocols, Wide Area Network

AF02-093 TITLE: Lightweight, Highly Deployable, Jam-resistant Satellite Communications Modem

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Design and build an ultra-efficient, low cost modem for airborne and ground wideband satellite communications.

DESCRIPTION: Currently, Military Satellite Communications (MILSATCOM) typically uses large, heavy ground terminals to communicate while deployed. Even if the weight of the electronics could be reduced, the antenna must remain large enough so that it can selectively point at only one satellite in space and not illuminate two satellites with its transmitted energy. A terminal with a very small antenna will only be allowed to transmit if it spreads its energy out across a wide bandwidth so that the interfering signal on the adjacent satellite appears as nothing more than background noise. This process is called direct sequence spread spectrum (DSSS). Military receivers for wideband DSSS are expensive (over $200k) and heavy (100 lbs.). Another benefit of DSSS is that it provides our lightweight deployable forces with a modest level of resistance to an unauthorized user or a jammer. This resistance to interference would be present regardless of whether the communication used military satellites or commercial satellites. DSSS would provide the DoD with its only jam resistant communications over commercial satellites. At the same time, the commercial wireless world will be experiencing a veritable explosion in its use of DSSS for the 3rd generation of the wireless internet (3G technology). Commercial receivers for reception of DSSS signals up to 10 miles away will be commonplace in 5-10 years. To apply this wideband (5 to 20 MHz wide) technology to military satellite communications presents unique problems in the tremendous distances (23,000 miles) to geostationary transponder satellites. The efficiency of the receivers for DSSS must be improved substantially. The approach recommended for investigation in this research topic promises to decrease the power required to communicate by a factor of 50 times. The production cost for a DSSS receiver would drop below the $10k price barrier. In addition, the weight of the terminal's modem would reduce to below 10 lbs. Low cost, small, lightweight, efficient, easily deployable, and jam-resistant make this technology a sure winner for both the DoD and the commercial worlds.

PHASE I: Determine the technical feasibility of utilizing this advanced DSSS modem technology for satellite communications. Quantify the efficiency improvements possible in CDMA networks using the technology. Develop a preliminary design for a Phase II prototype modem development. Computer simulate and/or prototype highest risk areas of modem development for Phase II.

PHASE II: Perform a detailed design of the prototype modem and a preliminary architecture for a proposed system to employ the modem for CDMA DSSS communications using transponded satellites. Simulate design through computer simulation or by analysis. Constuct breadboard CDMA DSSS communications system and demonstrate contractor/Air Force mutually agreed basic concepts.

PHASE III DUAL USE APPLICATIONS: The commercial wireless world is moving to wideband DSSS using code division multiple access (CDMA) techniques for sharing the same frequency channel. This technique would allow a single link to pass 25 to 60 times the data rate of a conventional DSSS link today. The commercial world would seize this technology in a heartbeat.

REFERENCES:
[1] Nassar, Dr. Carl (with Zhiqiang Wu). High Performance Broadband DS-CDMA via Carrier Interferometry Chip Shaping. Colorado State University/ECE Dept. Fort Collins, CO 80523-1373.
[2] TIA/TR45.5 The CDMA2000 ITU-R RTT Candidate Submission, July 1998[3] http://www.engr.colostate.edu/college/ee/pages/Research/rawcom, (CIDS-CDMA)

KEYWORDS: SATCOM, Modem, DSSS, Commercial, SHF, Wideband

AF02-094 TITLE: Signal Diversity Combining for Improved Satellite Communications

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Investigate signal diversity combining for reliable voice and data satellite communications to handheld and airborne terminals.

DESCRIPTION: Future UHF satellite communications systems are required to provide reliable high data rate communications to very small and disadvantaged terminals. The satellites will have very large antennas to be able to communicate with these terminals under various link-impaired conditions (interference, fading, multipath, ionospheric scintillation, etc.). However, because of power flux density limits imposed on satellite transmissions to Earth, satellite antennas and power amplifiers can not be built large enough to provide reliable communications under all link conditions. A way to improve communications performance is to use signal diversity combining techniques. This can be done if the same information signal is transmitted over multiple satellites and coherently combined at the receiving terminal. Depending on the order of diversity, the performance gains can be between a few decibels and tens of decibels in a fading environment. Orders of diversity of 2, 3 and 4 are generally enough to improve communications to high levels of availability for handheld and airborne terminals. In this task, the contractor is asked to develop, implement and test an optimum spatial signal diversity combining algorithm for satellite link environments that are degraded by noise, interference and fading using a single aperture receive antenna. Up to four separate satellite signal paths can be combined. The performance evaluation may be done for coherent and/or differentially coherent signal modulation schemes.

PHASE I: Develop a spatial signal diversity combining algorithm that has been optimized for a noise, interference and fading satellite link environment. Demonstrate its performance in simulated link conditions using bit-error-rate and combining gain as measures of improved performance. Develop a preliminary design for a hardware implementation of the algorithm, suitable for transition into Phase II.

PHASE II: (1) Finalize the design of the hardware implementation of the algorithm. (2) Implement the algorithm in hardware, integrate it into a satellite receiver and test it over real satellite links subjected to simultaneous noise, interference and fading conditions.

PHASE III DUAL USE APPLICATIONS: The signal diversity combining algorithm developed will provide more reliable communications to terminals in both military and commercial satellite systems. Terrestrial cellular mobile communications may also benefit from this algorithm.

REFERENCES:
[1] Winters, J. H., "Optimum Combining in Digital Mobile Radio with Cochannel Interference," IEEE Journal on Selected Areas in Communications, Vol. SAC-2, No. 4, July 1984, pp. 528-539.

[2] Lee, W. C. Y., Mobile Cellular Telecommunications, 2nd Ed., McGraw-Hill, Inc., 1995, Chapter 10.

[3] Tseng, S. H., "Optimum Diversity Combining and Equalization over Interference-Limited Cellular Radio Channel," IEEE Trans. Veh. Technol., vol. 47, No. 1, Feb 1998, pp. 103-118.

KEYWORDS: Satellite Communications, Signal Diversity Combining, Interference, Multipath Fading, Algorithms, Ionospheric Scintillation

AF02-096 TITLE: JAVA-Based, Performance Oriented Visualization System

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Development of a Java-based, performance-oriented visualization system that meets the stringent requirements of a Dynamic Battle Management (DBM) environment for Command and Control (C2).

DESCRIPTION: The Airborne Warning and Control System (AWACS) requires a modern Graphical User Interface (GUI) visualization system for the on-board workstations. A JAVA-based GUI will meet the needs of AWACS and provide a flexible, modifiable interface. The requirement is for a sophisticarted and well documented JAVA Application Programming Interfaces (APIs) that allows others to customize the API(s) specifically to an AWACS

block upgrade or to a new platform. Specific technology that needs to be explored for this development are; distributed objectsm dynamic plug-in applications, and object persistence. AWACS is looking to have state-of-the-art graphics capabilities on the aircraft.

Background: The term web-based Visualization has arisen from the changes in the way that the World Wide Web has been used. From the web's initial focus as an information repository, it has become a suitable environment for distributed computing. The use of the web for visualization purposes has evolved from descriptive methods, whereby images could be used to present findings, to analytical or exploratory visualization techniques. These methods exploit the potential of the distributed computing concept to allow the interactive investigation of visualization data. Visualization can also be defined as an approach in which a computer-generated visual representation is used to improve our understanding. This general definition encompasses diverse applications from data visualization - where numbers are turned into pictures - to virtual environments for training - where the subject is placed in visual reconstruction of a real environment. Recent advances in graphics workstations and virtual reality modeling languages (JAVA 3D)now allow the development of improved tools and processes supporting an improved visualization system environment.

For the warfighter, advanced visualization technology is necessary to help support an environment of shared information and provide a common operational picture of the battlespace for near-real time integration among the Joint C2 nodes. The visualization technology can improve dominant battlespace awareness at C2 nodes leading to superior situation awareness in providing the decision maker and warfighter crucial information in a timely manner. This battlespace awareness is a broad real-time knowledge of enemy activities, intentions, and capabilities; status and capabilities of Joint and Allied weapons and forces; and environmental factors, necessary for fully informed C2 decisions.

The(AWACS) is a C2 node that could greatly benefit from a JAVA-based performance-oriented GUI visualization system. AWACS is an airborne platform that performs surveillance, control, and battle management and communication functions. It provides air surveillance and control functions and may act as a Control and Reporting Center during theater operations. Data visualization technology applied to the AWACS will greatly help the processing of surveillance plot and track data, turning numbers into visual representations of the battlespace.

Development of a Java-based high level development tool suite and system is crucial in fulfilling the need for a GUI visualization environment. The visualization system must meet the stringent requirements of modern Command and Control and Weapons systems. The visualization software shall be designed in an object-oriented manner and have a robust Application Programming Interface (API) that permits extension and customization by third parties. It must be capable of processing plot and track data at sensor output rates and handle greater than 2000 tracks at a two-second update rate without performance degradation. It is critical that the software support a wide variety of data inputs via industry-standard mechanisms such as CORBA and TCP/IP. A completely flexible look-and-feel and dynamic plug-in architecture are also mandatory. The software must be as platform independent as possible and operate with the latest Java Virtual Machine (JVM) available from Sun Microsystems. At a minimum, the visualization software must support the following National Imagery and Mapping Agency (NIMA) map products: ADRG, CADRG, DTED, WVS, and CIB.

PHASE I: Develop a visualization system with the characteristics described above.

PHASE II: Develop the proposed visualization system and test the high level Java tools as they are developed against supplied representative data sets.

PHASE III DUAL USE APPLICATIONS: The contractor will integrate the tools into AWACS and verify that they meet or exceed the criteria of Phase I.

Dual Use Commercialization Potential: The visualization technology can be easily extended to the other Joint C2 nodes to provide a comprehensive and common operational picture of the battlespace. The technology can also support collaborative work environments so geographically separate military teams/organizations can work together at the same time. Visualization technology has already found wide acceptance in the commercial community. Colleges are using the technology to improve student training. The medical community is applying visualization technology to help radiologists improve their diagnosis, while geologists are using it for petroleum exploration and production. Much of the commercial visualization technology already developed could be applied to the military's C2 applications.

REFERENCES:
[1]Military Specification, MIL-A-87887, 22 Feb 1990, ARC (Equal ARC-Second Raster Chart) Digitized Raster Graphics (ADRG)

[2] Military Specification, MIL-C-89038, 6 Oct 1994, Compressed ARC Digitized Raster Graphics, (CADRG)
[3] Military Performance Specification, MIL-PRF-890202A, 19 April 1996, Digital Terrain Elevatrion Data, (DTED)
[4] Military Specification, MIL-W-89012, 27 Jul 1990 and Amendment 2, 30 Nov 1992, World Vector Shoreline (WVS)
[5] Military Performance Specification, MIL-PRF-89041, 15 May 1995 and Amendment 1, 31 Jul 1995, Controlled Image Base (CIB)

KEYWORDS: Data Visualization, Interactive Systems, Real-Time Systems, Graphical User Interface, Java Programming Language, Computer Graphics, Computer Animation, Visual Databases, Distributed Programming, Object-Oriented Programming

AF02-099 TITLE: Data Mining of GMTI Databases

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop concepts and techniques for data mining of Ground Moving Target Indicator (GMTI) databases. Warfighter Impact: GMTI databases have been developed with the ability to store and retrieve vast amounts of data from multiple platforms over a long period. This SBIR would provide a data mining capability to extract and exploit more information from databases of GMTI information.

DESCRIPTION: Ground Moving Target Indicator (GMTI) radar provides continuous wide area surveillance coverage of ground moving vehicles. Vast amounts of data are produced with every sweep of the radar sensor like the one utilized on Joint STARS. For example, the Moving Target Indicator Exploitation (MTIX) GMTI database program has the ability to store and retrieve GMTI data from multiple platforms and includes published APIs with available standard GMTI formats. Other databases are then populated with processed GMTI in the form of track, SAR, and report data.Data mining (sometimes called data or knowledge discovery) is the process of analyzing data from different perspectives and summarizing it into useful information. Both GMTI and GMTI Track databases contain historical records of ground entity movement, sensor noise, and sensor orbit patterns. The technical goal of this effort is the development of techniques to discover these patterns, perform statistical analysis to identify meaningful information, determine event detection possibilities, develop rules for event discovery, determine sensor management implications, and identify database deficiencies. Innovative research is required to utilize existing technologies (relational databases) and define new requirements (object-oriented databases) to perform data mining of the vast amount of data in the GMTI database(s). In order to fully exploit the information within those databases, new tools, techniques, and algorithms will need to be applied. The data can be from a particular day or over many days or months. The information to be mined can be used to perform the following sample tasks:-Vehicle (traffic) Flow Analysis - Behavioral Pattern Analysis-Vehicle Complex Movement Analysis-Sources and Sinks of Traffic-Track Patching/Continuity Improvement-Indications and Warnings (I&W) - find 9 to 5 traffic pattern-Display all Tracks Leaving Area (route history for selected AOI) Based on Filters-Display all Tracks Entering Area-Find Staging Areas

PHASE I: The Phase I effort will conduct the research required to define the technologies and algorithms needed to extract information from existing sample GMTI database(s). The focus of this effort will be on data stored in GMTI and GMTI track databases. The Phase I research will identify the critical technology challenges, investigate the likelihood of pattern existence, investigate utility, and define Phase II. Phase I risk reduction experiments/simulations will be conducted to demonstrate the feasibility of the proposed Phase II approach.

PHASE II: Develop algorithms and software algorithms to implement the approach developed in Phase I. The Phase II effort will implement and demonstrate the prototype data mining techniques and algorithms defined in Phase I within the GMTI database. A commercialization plan will be developed.

PHASE III DUAL USE APPLICATIONS: Air Force MTIX, Army CGS/JSWS systems, Navy TES (LSS) and Army TES, Oil Production Output Prediction, DOT Traffic Analysis, and Drug Enforcement.

REFERENCES:

KEYWORDS: MTIX, GMTI, MTE, Exploitation, JSTARS, Data Mining, Database, Warehousing, Data Archive, Information Management

AF02-100 TITLE: Coordinating Multiple Airborne Platforms to Improve Targeting Accuracy

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Quickly re-plan flight strategies to attain high targeting accuracy using multiple platforms and human input. Warfighter Impact: As new ISR information becomes available during a mission, quick route replanning and sensor retasking becomes a necessity to achieve time critical targeting. This SBIR will investigate strategies for replanning quickly to attain high targeting accuracy using multiple platforms and human interaction.

DESCRIPTION: Advances in cooperative Intelligence, Surveillance and Reconnaissance (ISR) collection have demonstrated opportunities to improve targeting accuracy, collection timeliness, and system throughput by adapting individual platform routings and sensor taskings in real-time. New information regarding the presence of "high priority" targets is available from a variety of intelligence sources. To quickly localize these high-priority targets, a small number of platforms from a larger set of integrated, cooperating collectors can be appropriated and re-tasked for a short time. In an operational setting, planning and tasking platforms require developing a unified plan, which may include: (1) choosing from among the available platform assets, (2) synchronizing assets, (3) determining sensing modes and scheduling each platform's sensors, (4) considering the likelihood of the target's existence and threat, and (5) developing platform trajectories. Generating these unified plans can require extensive time and computing power, but as new information becomes available during a mission, quick route re-planning (and sensor re-tasking) exercises become inevitable. The re-planning phase may consist of an automated decision aid that quickly evaluates re-planning opportunities, suggests candidate solutions, and determines the performance impact, safety, and cost of these modifications. Because these re-planning activities are time-critical, the original unified plan should be as robust and as insensitive as possible to subsequent re-planning perturbations. One approach for the generation of an effective and quick re-plan is to identify original planners that deliver (or can be modified to deliver) a family of plans that can be down-selected using data obtained in real-time, allowing the re-planning activity to maintain the effectiveness of the original plan. The re-planning method does not need to use the same techniques as the unified planner. For example rule-based technologies may be well suited to quickly determine an optimal plan from a family of plans. The rule-based system could encapsulate application specific heuristics and include analytic and expert knowledge of factors affecting the solution space size and characteristics. To achieve full operational viability, methods for incorporating human-like decisions into the automated system may provide for faster adoption to the field. For example, a mechanism to "learn" common human operator practices may be included. This "learning" of common usage modes (such as vetoing portions a subset of the automatically generated routes and taskings) can be incorporated gradually into the algorithm search directors and periodically encapsulated and reported to system administrators. These learned modes could be fully integrated in future upgrades. Investigating generalized solution encodings that can be easily modified to address dissimilar routing and resource allocation opportunities will allow flexibility and general application to both commercial and military applications. Although coordinating the strengths of various sensing methods among multiple platforms currently exists in other mission planning tools, this scenario is distinguished by its reliance on human interaction (with the associated ambiguities), the need to react quickly, and the complexities introduced by the need to deal with novel information quickly.

PHASE I: Survey current dynamic re-planning and re-tasking tools/algorithms that are being developed within the ISR communities. Evaluate candidate collection systems and obtain collection performance prediction models to be used for algorithm scoring. Design a method for determining unified plan robustness and for generating re-plans. Design an architecture for Phase II implementation and develop a proof-of-concept demonstration application. Concentrate on a small number of collectors (e.g. two) accounting for uncertainties in the problem, including those associated with humans who may have reported or interpreted evidence from the battle.

PHASE II: Increase the number of potentially retaskable platforms to a large number. Assume potential platforms to be retasked are currently tasked, requiring the platform selection decision to include consideration of the overall mission success. Define a model of the human component to augment evidence accrual. Demonstrate a prototype of the retasking procedure that clearly shows useful information gained while attaining acceptable risk levels

PHASE III DUAL USE APPLICATIONS: Commercial applications include logistics routing and resource allocation problems such as transit bus routing and intra-modal truck/rail routing, and developing civilian evaculation plans for natural and manmade disasters.

REFERENCES:
[1] Advanced ISR Management (AIM) DARPA Program

KEYWORDS: Replan, Multi-Platform, Decision Support Systems, Dynamic Replanning, Rescheduling, Dynamic Sensor Tasking, Cognitive Psychology

AF02-101 TITLE: Feature Aided Tracking (FAT) to Augment Track Continuity

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop automated tools to utilize the radar features in Ground Moving Target Indicator (GMTI) trackers to improve moving vehicle track continuity. Warfighter Impact: This Feature Aided Tracking SBIR will develop the capability for GMTI trackers to maintain tracks of individual vehicles over long time periods, through dense environments, terrain obscuration, vehicles falling below MDV, and sensor platforms going into turns.

DESCRIPTION: Ground Moving Target Indicator (GMTI) radar provides continuous wide area surveillance coverage and precision tracking of ground moving vehicles. GMTI trackers provide direction and velocity of ground moving vehicles but have difficulty maintaining track of a vehicle over a long period of time (> 10 minutes) or distinguishing one vehicle from another. Current GMTI trackers default to group tracking in dense vehicle environments, or lose track during complex vehicle movements or over long periods of time. Dense vehicle environments, terrain obscuration, vehicles falling below the Minimum Detectable Velocity (MDV), and sensor platforms going into turns all lead to track breaks.Innovative algorithms and software automation techniques are required to increase the track duration of the vehicles through the exploitation of various radar features. The features include but not limited to: Doppler, Radar Cross Section (RCS), High Range Resolution (HRR), RF TAGS (for friendly forces), and Terrain.

PHASE I: Conduct the research needed to define the radar feature attributes that can be used to improve track maintenance. Feature Aided Tracking techniques will need to address dependencies like angle, range, and speed attributes. The Phase I research will identify the critical technology challenges, the algorithms, and automation tools that need to be developed. Phase I will also define a prototype implementation that can be accomplished in Phase II. Phase I risk reduction experiments/simulations will be conducted to demonstrate the feasibility of the proposed Phase II approach.

PHASE II: Implement the prototype identified in Phase I. All developed algorithms and automation tools will be demonstrated and documented as to their capabilities and limitations. A commercialization plan will be developed.

PHASE III DUAL USE APPLICATIONS: This technology could be used in a broad range of military and civilian applications where automatic surveillance, tracking and identification are necessary. Known civilian application areas include commercial aviation, Intelligent Vehicle Highway Systems (IVHS), drug enforcement, transportation system, and security in industrial facilities.

REFERENCES:

KEYWORDS: Tracking, Multi-INT Fusion Algorithms, Correlation, Data Alignment (spatial and temporal) Algorithms

AF02-102 TITLE: Spectral Filtering

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop very low power FFT, DEF, and IFFT implementation on an ASIC chip.

DESCRIPTION: Frequency domain digital signal processing offers enhanced performance for navigation, radar, communications and computer systems with less complex hardware implementation. A major application of frequency domain processing is in the area of adaptive filters for the excision of narrow band jamming waveforms in spread spectrum systems, such as the Global Positioning System (GPS). As jamming power increases, the need exists for filters with jamming suppression capabilities approaching 60 dB. Simulations have shown that these suppressions can be obtained by processing in the frequency domain. The current Fast Fourier Transforms (FFTs) dissipate excessive amounts of power and are therefore not applicable for many GPS receivers such as handhelds. A need exists for the development/demonstration of a low power, low cost and small size FFT, DEF and IFFT (Inverse Fast Fourier Transform) prototype chip which can be integrated in a handheld GPS receiver.The chip will perform three functions:(a) a Fourier transform (b) a filtering function (including the possibility of an excision filter)(c) an inverse Fourier transform For real-time applications, the chip will need to continuously output the results of a 1024-point complex transform(the industry standard) using the above computations [(a)-(c)] every 10 microseconds. In addition, the chip will needto be low power (much less than 100mW) to permit its application in wireless applications.

PHASE I: 1) Investigate technologies applicable to the design of a low power, low cost, small size FFT/DEF/IFFT chip meeting the requirements above.2) Develop detailed models of candidate FFT/DEF/IFFT chip designs. 3) Perform

analyses/cost and trade studies. 4) Select final design based upon performance/cost/power criteria. 5) Based on selected design, provide a limited proof-of-concept demonstration to mutually (Air Force/contractor) agreed specifications. The basic focus would be the integration by simulation with a GPS receiver in the loop.

PHASE II: 1) Produce final detailed design of the FFT/DEF/IFFT chip.2) Produce a production prototype FFT/DEF/IFFT chip capable of demonstrating all key performance features. 3) Conduct tests/demonstrations to mutually (Air Force/contractor) agreed specifications to measure/verify FFT/DEF/IFFT chip performance. Provide final FFT/DEF/IFFT chip cost/power analysis.

PHASE III DUAL USE APPLICATIONS: Development/integration of a FFT/DEF/IFFT chip has both DoD and Commercial application in the future for communication. Currently 1 Watt FFT is available as COTS (commercial off the shelf).

REFERENCES:
[1] "CMOS building blocks shrink and speed up FFT systems," INSPEC (Dialog® File 2): (c) 1998 Institution of Electrical Engineers. 02991081 INSPEC Abstract Number: B87066010, C87059668
[2] "A high-speed FFT processor," INSPEC (Dialog® File 2): (c) 1998 Institution of Electrical Engineers. 01233934 INSPEC Abstract Number: B78039301
[3] "Efficient hard-wired digital fast -Fourier -transform processor," INSPEC (Dialog® File 2): (c) 1998 Institution of Electrical Engineers. 01122020 INSPEC Abstract Number: B77043037, C77027026

KEYWORDS: Digital Excision Filter, Narrowband Interferers, GPS Receiver, Fast Fourier Transform, CMOS (Complimentary Metal-Oxide Semiconductor), ASIC (Application Specific Integrated Circuit)

AF02-103 TITLE: Innovative Information Technologies

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop innovative information technologies for enhancing the performance, availability, and affordability of C4I systems and subsystems.

DESCRIPTION: Proposals may address any aspect of Information pervasive technologies not specifically covered by other SBIR topics. Areas of interest include, but are not limited to, innovative concepts and technologies in: Global Awareness, Dynamic Planning and Execution, and Global Information Exchange. 1. Global Awareness -- Global Awareness entails the affordable operational capability, from local to global level, for all pertinent personnel to understand militarily relevant situations on a consistent basis with the precision needed to accomplish the mission. Specific areas of interest include: - Information Exploitation -- Image/Video/Text -- Signals - Information Fusion -- Information Fusion comprises situation assessment, impact assessment and process refinement. Innovative solutions to accurately perform situation assessment, identify current and future threats to blue forces, the ability to adapt to new patterns/environmental situations, as well as provide feedback to the data collection process are all highly desired. - Global Information Base: This is defined as a distributed, heterogeneous data/information management system which stores Global Awareness information, and provides information services to Dynamic Planning and Execution operations. 2. Dynamic Planning and Execution -- This thrust concentrates on the aerospace commander's ability to rapidly acquire and exploit superior, consistent knowledge of the battlespace through a worldwide distributed decision-making infrastructure of virtual battlestaffs and intelligent information specialists. Specific areas of interest include: -- Configurable Aerospace Command Center -- Time Critical C2 -- Real-Time Sensor-to-Shooter Operations -- Targeting - Joint/Combined Coalition C2: There is a critical need for the capability and enabling decision-making infrastructure needed to achieve dynamic synchronization of large-scale missions and resources from components and coalition forces. This area will seek to develop new command and control technology enabling a future coalition planning staff to take into consideration the differing influences of all members of a coalition force; including differing military Rules Of Engagement (ROE), force structures, authority roles, capabilities, doctrine, and culture. - Collaboration/Simulation/Visualization: This technology will provide planners and decision makers with the ability to view, understand, and analyze the vast amounts of information available from C4ISR systems. Collaborating teams require a common, shared context data environment where the visualization of the data is tailored to the application domain and the user preference. Specific modeling and simulation capabilities will assist in both proactive and reactive assessment. 3. Global Information Exchange -- Global Information Exchange is the ability to interconnect all members of the Air Force via a netted communication and information system, available anywhere, at any time, and for any task or mission. Specific areas of interest include: - Global Communications: The technical goals center on wireless information exchange systems and technologies that interconnect remotely separated command and control systems and users, providing high quality, timely, secure, and low probability of exploitation communications to air, land, and space. The required capabilities provide line-of-sight

and beyond-line-of-sight connectivity spanning the frequency ranges "from DC to light," in point-to-point, broadcast, or networked modes. -- Multiband/Multifunction Communication Systems -- Robust Tactical/Mobile/Wireless Networks -- RF Communications Systems - Defensive Information Warfare (DIW): DIW is concerned with the defense of friendly information systems and signatures and ensuring the authorized use of the information spectrum. This technology seeks to protect against corruption, exploitation, and destruction of friendly information systems; ensure confidentiality, integrity, and availability of systems; integrate actions (offense, defense, and mitigation) to ensure an uninterrupted flow of information for weapons employment and sustainment. -- Information Systems Protection -- Attack Detection -- Computer Forensics -- Secure Computing

PHASE I: Provide a report describing the proposed concept in detail and show its viability and feasibility.

PHASE II: Fabricate and demonstrate a prototype device, subsystem, or software program.

PHASE III DUAL USE APPLICATIONS: Many Information Technologies have substantial dual-use potential and will impact competitiveness and performance of the commercial sector as well as the military sector. All solutions proposed must have potential for use/application in the commercial as well as military sector, and potential commercial applications must be discussed in the proposal.

REFERENCES:

KEYWORDS: Information Technology, Command and Control, Communications, Computers, Intelligence, Global Awareness, Dynamic Planning and Execution, Global Information Exchange

AF02-104 TITLE: Innovative Approaches for Information Fusion

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Development of mathematically rigorous techniques for situation assessment and impact assessment.

DESCRIPTION: The Joint Directors of Laboratories (JDL) Subpanel on Data Fusion originally defined Data Fusion as "a process dealing with the association, correlation, and combination of data and information from single and multiple sources to achieve refined position and identity estimates, and complete and timely assessments of situations and threats, and their significance. The process is characterized by continuous refinements of its estimates and assessments, and the evaluation of the need for additional sources, or modification of the process itself, to achieve improved results".Steinberg, et al [Reference 1] later defined data fusion as "the process of combining data to refine state estimates and predictions." A breakout of the functional levels [1] is: · Level 0 - Sub-Object Data Assessment: estimation and prediction of signal/object observable states on the basis of pixel/signal level data association and characterization; · Level 1 - Object Assessment: estimation and prediction of entity states on the basis of observation-to-track association, continuous state estimation (e.g. kinematics) and discrete state estimation (e.g. target type and ID); · Level 2 - Situation Assessment: estimation and prediction of relations among entities, to include force structure and cross force relations, communications and perceptual influences, physical context, etc.; · Level 3 - Impact Assessment: estimation and prediction of effects on situations of planned or estimated/predicted actions by the participants; to include interactions between action plans of multiple players (e.g. assessing susceptibilities and vulnerabilities to estimated/predicted threat actions given one's own planned actions); · Level 4 - Process Refinement (an element of Resource Management): adaptive data acquisition and processing to support mission objectives.Information Fusion is the subset of data fusion that primarily focuses on situation assessment and impact (threat) assessment activities.Browsing through the various conference proceedings, journals, and books pertaining to data fusion, it becomes clear that the majority of research and research applications to date have focused primarily on Level 1 fusion. The main reason for the abundance of Level 1 activities is that the research community understands well how to extract relevant data about physical objects. For example, if your goal is to identify an object such as a fruit, the physical properties that would be used to describe it would be it's shape, color, texture, etc. These are physical properties that one can easily measure and comprehend. Similarly, if your goal is to identify an automobile or a tank, then again the physical attributes might include length, width, number of wheels, number of tracks, etc. However, when one addresses the higher levels of data fusion, the emphasis is no longer on physical objects, but the relationships amongst the various objects. And those relationships, particularly for impact assessment, are poorly understood.Specific areas of research within Information Fusion are:1. Development of a rigorous mathematical basis for information fusion;2. Novel approaches for inferring relationships amongst battlesphere entities and events;3. Strategies for information gathering and planning dealing with uncertain, incomplete and ambiguous data/information;4. Determining the current (and future) threats/impacts.

PHASE I: Develop a mathematically sound approach to a subset of the situation assessment or impact assessment function areas within Information Fusion.

PHASE II: Develop a prototype Information Fusion system based on the Phase I design. Demonstrate the developed Information Fusion capability in a realistic environment.

PHASE III DUAL USE APPLICATIONS: There are many dual use applications of Situation Assessment and Impact Assessment techniques. For example in the automotive industry, research is being performed for the use of Infrared Imaging, to detect animals and pedestrians near the roadways. By combining this information with a laser ranging capability, this fused information could then be used to perform situation assessment and perhaps initiate an operator alert or a breaking sequence. A broad range of military applications exist for this topic area.

REFERENCES:
[1] A. Steinberg, C. Bowman, F. White, "Revisions to the JDL Data Fusion Model", Proc. Of the SPIE Sensor Fusion: Architectures, Algorithms, and Applications III, pp 430-441, 1999.

[2] E. Waltz and J. Llinas, "Multisensor Data Fusion", Artech House, 1990. [3] R. Antony, "Principles of Data Fusion Automation", Artech House, 1995.

KEYWORDS: Information Fusion, Data Fusion, Situation Assessment, Threat Assessment, Impact Assessment, Correlation

AF02-106 TITLE: Quantum Information Science

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: To exploit quantum phenomena and develop quantum information sciences technology.

DESCRIPTION: The quantum information sciences are a broad category of technology that can enable such things as the efficient solution of non-polynomial complete problems in polynomial-time, information assurance, protected transmission and the fast training of neural networks and intelligent agents. Research topics should concentrate on, but are not limited to, the development of algorithms, secure information handling, neural networks, artificial intelligence, quantum photon transmission of data, and data compression via entangled states. Specific hardware devices are not within the scope for this call.

PHASE I: Phase I activity shall include as a minimum: 1) A thorough review of classical solutions to selected issues compared with proposed quantum solutions, 2) Design and/or model of large scale solutions, and 3) Limited demonstration of technique on an applicable/scalable problem.

PHASE II: Phase II activity shall include as a minimum: 1) final development of selected method as it applies to a scalable demonstration problem or system, 2) a prototype demonstration of solution or system with forecasted improvements, and 3) a comparative cost/effective analysis of developed approach compared with classical solutions.

PHASE III DUAL USE APPLICATIONS: QuIS technology will be applicable well beyond DoD and Government applications, they will also be applicable to the commercial world in areas of massive-speed up calculations. QuIS endeavors will benefit areas where classical means have failed.

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[5] R. Feynman, "Simulating physics with computers" Interaction Journal of Theoretical Physics, Vol. 21 No. 6/7, pp. 467-488 (1982).

KEYWORDS: Quantum Algorithms, QKD, Quantum Transmissions, Entangled Pairs, Unconditionally Secure Information Transmission

AF02-107 TITLE: HPC for C2 Decision Support

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop HPC Real-time command and control decision support technology.

DESCRIPTION: Simulate and analyze Course Of Actions (COAs), in real-time, based on executable scenarios established utilizing Effects Based Operation (EBO) planning techniques. The major advantage of EBO, using the enemy-as-a-system concept, is that it explicitly seeks to understand, trace and anticipate the direct and indirect effects that planned actions have on an enemy's center of gravity. Every planning operation evaluates alternative before the final plan selection. EBO based plans provide a unique view on which alternative plans are generated. Dynamic force structure simulations based on these plans will simulate the resulting COAs in real-time for immediate selection and execution. By simulation the EBO interactions, simulation tools can effective predict the effects a directed course of action will cause. Each battlefield scenario produces unique process graphs to simulate, the ability to parallelize the simulation in an adaptive manner addressing real-time constraints should lead to great improvements in both throughput and latency. This speedup will allow more alternate courses of action to be evaluated within a restricted timeframe, resulting in higher quality battlefield execution plans that can be adapted within the enemy's decision cycle

PHASE I: Develop parallel force structure analysis techniques that support:
1) Multi-faceted force structure behavioral models that can simulate the interactions necessary to achieve indirect effects based upon direct actions.
2) Dynamic rules of engagement and rapid course of action analysis techniques of force structure simulation.
3) Automated scenario generation based on extracting the battlespace knowledge from intelligence, reconnaissance and surveillance data.
4) Dynamic models that morph as real-time constraints are introduced.

PHASE II: An analysis system will be designed, developed and demonstrated based on the analysis technique or techniques evaluated or established in phase I. The demonstration should be based on a realistic sized scenario. A detailed phase III plan will be developed.

PHASE III DUAL USE APPLICATIONS: Real-time decision support and predictive analysis tools are necessary for any industrial organization providing time critical services subject to uncontrolled events. For example, travel services, delivery services, production and manufacturing, entertainment services all plan and establish contingency alternatives.

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[1] J. Steinman, "Scalable Parallel and Distributed Military Simulations Using the SPEEDES Framework," Elecsim 95, 1995.
[2] Headquarters Air Force Doctrine Center, "Doctrine Watch #13: Effects-Based Operations (EBO)", Article Date: 30 Nov 2000
[3] Dr. Maris McCrabb, "Concept of Operations for Effects-based Operations", Version 2, AFRL/IFTB, July 11, 2000

KEYWORDS: Automated Scenario Generation, Force Structure Simulation, Dynamic Model Behavior, Real Time Decision Support, Parallel Event Simulation, Effects Based Operation, Course of Action Analysis, Command and Control

AF02-108 TITLE: Configurable Enterprise Test Harness for Publish and Subscribe Architectures

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop a configurable test harness that facilitates enterprise performance assessment of publish and subscribe (P&S) architectures.

DESCRIPTION: A Publish and Subscribe (P&S) architecture is composed of protocols, processes, and common core functions that permit participating applications and organizations to share and exchange critical data in a timely manner. In [1], the Air Force Scientific Advisory Board defined its vision of a Joint Battlespace Infosphere (JBI) which will enable military users to seamlessly integrate the information systems and data needed to conduct a single mission. In addition, numerous commercial firms are developing P&S standards and products that may form the basis for a comprehensive JBI platform. Given this critical mass of effort, the Air Force needs a test harness to assess and compare different P&S architectures. This capability would allow evaluators to design, simulate, execute, monitor, and report on scenarios that stress P&S system performance for a given enterprise. These scenarios are characterized by a representative set of information producers and consumers (clients) that populate a given infosphere. While a

predefined library of such components is required, the scenario designer must be able to tailor them in terms of type, system load profile, and pedigree characteristics (e.g., priority, reliability, security level). Once execution of the scenario begins, the harness must simulate these components according to the selected parameters. More generalized scenario attributes might include operational tempo, enemy interference levels, and specification of mission events. A key design goal is that the harness be architecture and platform neutral; it must be easily reconfigured for the protocols and characteristics of the particular P&S system under evaluation. During a given scenario run, the harness must monitor, collect, and archive critical performance data at the system level and for selected client entities. The harness must include post-processing tools that visualize/summarize the performance at the appropriate level after a given scenario run. In addition, automated report generation tools will be provided to compare performance across scenarios for the same or different systems. As a design goal, the harness should (to the greatest extent possible) conform to industry benchmarking standards and practices.

PHASE I: At the end of the initial phase, we expect a prototype scenario generation tool. The contractor will demonstrate the utility of this tool in generating simulated clients for a sample operational scenario. In addition, the contractor will produce a design for a full enterprise test harness. As part of this effort, the contractor will demonstrate how the design leverages industry standard benchmarks and supports evaluation of multiple P&S architectures.

PHASE II: At the conclusion of this phase, the contractor will deliver a fully functional enterprise test harness. This package must include a set of evaluation/reporting tools (as outlined in the above description) and be compatible with accepted industry benchmarking standards. As part of the effort, the contractor will demonstrate the harness on at least three (3) different P&S systems operating on at least two (2) types of platforms. Heavy emphasis will be put on the versatility of the scenario generator and the ease with which the harness can be reconfigured to evaluate new systems. In addition, the contractor must validate the accuracy, fidelity, and integrity of the scenario simulation and the performance evaluation/reporting tools.

PHASE III DUAL USE APPLICATIONS: The proliferation of e-commerce standards such as the Extensible Markup Language (XML) and Simple Object Access Protocol (SOAP) is serving to fuel development of distributed P&S architectures. As with other types of enterprise critical systems (such as e-mail servers), there will be a tremendous need for both industry and the DOD to evaluate and compare competing P&S architectures and products. Because P&S is a relatively new paradigm, the to-date focus has been on standards development rather than implementation assessment. As P&S products supporting these standards are deployed over the next few years, we expect that emphasis to slowly change. By the conclusion of this effort, we anticipate significant demand in both the commercial and DOD markets for a test harness that simulates activity for a given enterprise and measures the associated P&S architecture performance. The contractor could market this system as a stand-alone product or as part of a comprehensive evaluation service.

REFERENCES:
[1] United States Air Force Scientific Advisory Board, Report on Building the Joint Battlespace Infosphere, SAB-TR-99-02, http://www.sab.hq.af.mil/Archives/index.htm, December 17, 1999.

KEYWORDS: Publish and Subscribe, Enterprise Architecture, Test Harness, Benchmarking, Test Scenario, Simulated Client, Performance Evaluation

AF02-109 TITLE: Multisensory Assimilation of Complex C2 Information

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Explore multi-sensory assimilation systems for the purpose of providing decision-quality Command and Control information for both ground-based and airborne applications.

DESCRIPTION: In order to wage a successful campaign, next generation mission/battle commanders and air controllers will need to assimilate a tremendous glut of available information, from a wide variety of sources and types; ranging from hardcopy HUMINT to real-time sensor feeds. Armed with this data (some raw, some fused), they will be expected to see through the "fog of information" and make quick-response decisions - and to quantify the effects of those decisions - all in the face of uncertainty. It is a daunting task for which systems and tools available to current Command Centers and airborne control platforms offer no solution.That decision support systems for any domain are dramatically improved by the addition of some degree of visualization is inarguable. To date, however, even the most state-of-the-art visualization approaches concern themselves with visualization of data; e.g., terrain, maps, iconic depictions of threat laydowns and flight packages, etc. But data is not information, and it is information that the commander needs to wage his campaign or the airborne controller to control airspace. The proposed topic will explore multi-sensory assimilation systems and techniques that will improve the decision-maker's understanding of the myriad

of information sources and types presented to him; tailoring the information to best support his decision processes. Proposers to this topic are to explore one or more of the following major focus areas:Multi-sensory assimilation systems. This area concerns itself primarily with determining the best mix of visualization paradigms (e.g., 2D, 2 ½D, 3D, 3D+time, stereoscopy, animation, etc) and sensory input, presentation and interface techniques (for example, tactile, haptic, voice, gesture recognition, use of color, texture maps, 2- and 3-D Audio, etc.) Specific effort should be expended to address the scientific basis for, and the human/psychological factors behind, a design for a multi-sensory visualization component; that is, it should address questions of the sort "Does the use of 3-D in a command center facilitate better human understanding of, and interaction with, information/data being presented, or does it further exacerbate information fatigue?" or "Is there a "best" color or presentation technique - perhaps blinking or an audio alarm - to get a user's immediate attention?" Also covered in this area are new approaches for decision-makers to interact with data - raw or fused - and information being presented.Information Visualization Techniques. This area involves technology approaches for a) visualizing the "invisible" aspects of a situation (examples for the military might include portrayals of threat envelopes, multi-source state information of adversarial air assets, effects of jamming on the range of coverage of an air defense radar, etc. More general examples include weather patterns and effects, chemical cloud dispersion, safe air corridors for air traffic control, population density overlays, etc.), b) depiction of complex information from multiple disparate sensors and information sources to facilitate command decision processes, c) "filtered representation" of information (i.e., "decision-quality information"); such as a combatant's strength, will, intent, degree of uncertainty of perceived data, and d) modeling today's human fusion processes; i.e., fusion levels 2 and 3.

PHASE I: Develop an overall system design and concept of operations for an advanced multi-sensory C2 information visualization system/component.

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to prove the feasibility over extended operating conditions. Of paramount importance is a quantified measure of the worth of such a system to the warfighter/decision-maker.

PHASE III DUAL USE APPLICATIONS: This capability could be used in a broad range of military and civilian applications to improve or supplement decision support systems that are, or will soon be, overrun by rafts of disparate uncorrelated information. Advanced Information Visualization techniques and systems show great promise for intelligently filtering superfluous data, fusing relevant data into meaningful information, and otherwise dissipating the "fog of information" faced by the decision-maker of tomorrow.

REFERENCES:

KEYWORDS: Information Visualization, Human Factors, multi-sensor input, multi-sensor fusion

AF02-110 TITLE: Secure Peer-to-Peer Object Repository

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Design and prototype a secure, distributed object repository based upon peer-to-peer file sharing technology/tools/protocols.

DESCRIPTION: New military enterprise information management concepts like the Global Information Grid (GIG) and the Joint Battlespace Infosphere (JBI) [1], envision a globally accessible, secure, distributed information "space" where personnel from all echelons can go to find relevant, tailored "decision-quality" information in support of critical decision-making efforts. While a wide variety of approaches may be envisioned to implement such a repository, the peer-to-peer (P2P) model is one that has not been explored systematically. The P2P information-sharing paradigm is one that holds significant potential utility for such large-scale repositories due to its inherent scalability, de facto standardization, decentralized architecture, and low cost of entry. The recent proliferation of P2P technologies, such as GNUtella, Infrasearch, Napster, and Filenet have provided tangible examples of the power of the P2P model to facilitate global information exchange and influence the evolution of e-business. These modern implementations, however, focus on specific files and file types rather than more generic information objects and do not address security to a large degree. This effort will address the applicability of P2P architectures to the concept of secure, large-scale, distributed object repositories and seek to develop a prototype implementation. A key question will be how to ensure and manage security effectively. Factors such as technical feasibility, economic affordability and operational utility must be weighed in as part of this investigation.

PHASE I: Evaluate current P2P technologies for potential as platforms to provide a secure, distributed, large-scale object repository for an enterprise environment. Develop an approach for ensuring the manageability and security of a

large-scale distributed object repository based on the P2P model. Assess the feasibility of this approach. Develop a design for a secure P2P object repository for generic information objects.

PHASE II: Develop and demonstrate a prototype secure P2P object repository addressing the key questions and factors listed in the Description above and based on the design in phase I. This prototype should be implemented to demonstrate how secure P2P technology can satisfy the principles embodied in a publish- subscribe and query architecture as described in [1].

PHASE III DUAL USE APPLICATIONS: Secure P2P Object Repository technology could be ideal for supporting rapidly deployable, "come-as-you-are" distributed command and control systems in which mission data is often spread across the various component applications of the system. The inherent discovery-based nature of P2P technologies eliminates the need for extensive coordination and planning of information requirements. Likewise, with the increasingly shortening business cycle, the ability of corporations to rapidly form and disestablish alliances will require information systems that are capable of interoperating in a distributed and opportunistic fashion; while providing levels of information assurance and security comparable to those expected by the DoD.

REFERENCES:
[1] United States Air Force Scientific Advisory Board, Report on Building the Joint Battlespace Infosphere, SAB-TR-99-02, http://www.sab.hq.af.mil/Archives/index.htm, December 17, 1999.

[2] J. Evans, J. Niccolai, P-to-P Moves Beyond Napster, InfoWorld, Feb 13, 2001.http://www.infoworld.com/articles/hn/xml/01/02/13/010213hnp2ptime.xml

[3] Related topic: AF02-108 "Configurable Enterprise Test Harness for Publish and Subscribe Architectures"

KEYWORDS: Peer-to-Peer, Data Repository, Objects, Information Security, Protocol, Information Management, Architecture

AF02-111 TITLE: Casting Hard Alpha Inclusion Detection

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop a novel approach to detect and characterize hard alpha inclusions in 6Al-4V beta annealed titanium castings.

DESCRIPTION: Hard alpha inclusions are defects that can occur in titanium castings from contamination in the casting process. This contamination typically results from metallic material, such as splatter from welding or torch cutting operations. As they are of similar density as surrounding material, they are undetectable via radiography. Phased array ultrasonic techniques have shown some success in finding these defects, especially as porosity and/or cracking is often associated with these defects. These defects are surrounded by a halo region enriched with oxygen and nitrogen, typically doubling the effective size of the defect. These halo areas have been undetectable by any method. This topic seeks proposals for innovative approaches to detect and characterize hard alpha inclusions in 6Al-4V beta annealed titanium castings, including the defect and its associated halo.

PHASE I: Develop and demonstrate the feasibility of a nondestructive inspection technique capable of detecting hard alpha inclusions buried in titanium. Demonstrate the technique on representative coupons or samples.

PHASE II: Optimize the inspection technique and develop a prototype inspection system. Demonstrate the prototype system capabilities on representative aircraft components in a production environment.

PHASE III DUAL USE APPLICATIONS: This technology would be directly applicable to military or commercial aircraft, using cast titanium as the primary load-carrying structure.

REFERENCES:
1. J.D. Cotton, L.P. Clark, T.R. Reinhart, W.S. Spear, S.J. Veeck and G.R. Strabel, "Inclusions in Ti-6Al-4V Investment Castings," Paper #AIAA-2000-1464, 41st AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference and Exhibit, 3-6 April 2000, Atlanta, GA.

KEYWORDS: hard alpha inclusions, titanium, castings, nondestructive inspection

AF02-112 TITLE: Lightweight Titanium Heat Exchangers

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop and characterize optimum joining techniques for high strength, high temperature, reliable plate-fin titanium heat exchangers for liquids in advanced aircraft engine and airframe applications.

DESCRIPTION: To date, high temperature heat removal in advanced military aircraft has been accomplished with heat exchangers fabricated out of stainless steel or inconel materials. Unfortunately, these metals are heavy and make it difficult to produce weight-efficient designs. For this reason, there is a need to utilize lighter weight materials which can offer similar or better performance at lower weight and cost. As an example, the next generation of weapon systems, Joint Strike Fighter (JSF), requires a lightweight heat exchanger system in order for the weapons system to meet weight and cooling requirements. Titanium (Ti) is one material that can fulfill this requirement. However, before Ti can be fabricated into lightweight heat exchangers, work is needed to further develop thin sheet forming and joining processes such as brazing of thin, 0 .004- to 0.020- inch thick Ti materials. This program will: 1) select materials for bars, parting sheets, fins and header details within a heat exchanger; 2) select braze alloy/s; 3) perform material characterization.

PHASE I: Survey the Ti community for candidate titanium materials and select one or more materials which would be suitable for the brazing of thin section details. Selection criteria should include consideration of material costs and scalability of fabrication technique, as well as performance and maintainability issues. Fabricate coupons and subject them to a battery of mechanical tests. Assess the test results, identify material process refinements, and identify the most promising brazing process and materials.

PHASE II: Optimize the processing and performance of the chosen Ti materials through fabrication and testing of: 1) lap-joint braze coupons, 2) three-layer core samples: and 3) full-size representative heat exchangers.

PHASE III DUAL USE APPLICATIONS: The resulting brazing process will be directly applicable to commercial aircraft and engines structures as well as heat exchangers. This process can also be used in marine applications as well.

REFERENCES:
1. Davis, Joseph R.; Kelly Ferjutz; Nikki D. Wheaton. ASM Handbook: Welding, Brazing, and Soldering. 10th Edition, Vol. 6, 1994.

KEYWORDS: titanium, welding, brazing, heat exchanger

AF02-113 TITLE: Component Surface Treatments for Engine Fatigue Enhancement

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop and demonstrate affordable component surface treatments for increased fatigue life and improved foreign object damage tolerance for rotating engine components.

DESCRIPTION: Due to the projected costs of future gas turbine engines, component durability has been gaining significant visibility over the past several years. Many approaches are being considered to improve the durability of both fielded and future engines. Chief amongst these concepts is that of applying compressive residual stresses to rotating engine components via surface treatments. Shot peening has long been used to impose such stresses to fatigue-critical components. This process produces compressive stresses only very near the component surface, and relatively high levels of cold work, the latter leading to thermal relaxation of these stresses should the component be exposed to elevated temperature. More recently a number of surface treatment processes have been developed which result in higher levels of compressive stresses at much greater depths than shot peening. In addition, these processes produce only very modest levels of cold work, yielding compressive stresses with much improved thermal stability. These processes include, but are limited to, laser shock peening (LSP), lasershot peening, and low plasticity burnishing (LPB). Although these processes are at various stages of development from a manufacturing standpoint, they all suffer from a lack of understanding of the resulting three-dimensional state of stress and how this stress state impacts fatigue life and foreign object damage resistance. This solicitation will address these fundamental issues and to develop a proven methodology for the application of component surface treatment technologies to improve engine durability.

PHASE I: Demonstrate mechanical performance benefits (high cycle fatigue, low cycle fatigue, and foreign object damage tolerance for example) of component surface treatment on coupon specimens if data does not already exist.

Develop preliminary processing techniques for the application of component surface treatments to representative turbine engine hardware.

PHASE II: Optimize processing parameters and demonstrate performance enhancements through bench or subsystem testing of engine components. A detailed stress analysis, fatigue characterization, and destructive/nondestructive material damage assessment will be conducted to validate the approach.

PHASE III DUAL USE APPLICATIONS: Commercial aircraft engines are also limited by fatigue performance. Successful application of optimized and fundamentally understood component surface treatments will result in improved engine durability in the commercial sector. Any industry where components are limited by fatigue life or foreign object damage tolerance could potentially benefit from successful implementation of this program.

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1. A.H. Clauer, J.H. Holbrook, and B.P. Fairand, "Shock Waves and High-Strain-Rate Phenomena in Metals," edited by M.A. Meyers and L.E. Murr, (Pub. Plenum Publishing Corp., New York, 1981) p. 675-702.

2. P. Peyre and R. Fabbro, Optical and Quantum Electronics, Vol. 27, 1995, p. 1213-1229.

3. A.H. Clauer, J.K. Lee, R.A. Brockman, W.R. Braisted, S.A. Noll, and A. Gilat, "Modeling Residual Stresses After Laser Shock Peening," Proceedings of the 5th National Turbine Engine High Cycle Fatigue (HCF) Conference, March 2000, Chandler, AZ.

4. J.R. Ruschau, R. John, S. Thompson, and T. Nicholas, Journal of Materials and Technology, Vol. 121, July 1999, p. 321-329.5. P.S. Prevey, D. Hornback, and P. Mason, "Thermal Residual Stress Relaxation and Distortion in Surface Enhanced Gas Turbine Components," ASM/TMS Materials Week, Indianapolis, IN, 1997.

5. P.S. PREVÉY, D. HORNBACH, and P. MASON, "Thermal Residual Stress Relaxation and Distortion in Surface Enhanced Gas Turbine Components," ASM/TMS Materials Week, Indianapolis, IN, 1997.

KEYWORDS: laser shock peening (LSP), low plasticity burnishing (LPB), high cycle fatigue (HCF), component surface treatments

AF02-114 TITLE: Corrosion Preventative Coatings

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop tunable adhesion coatings (release-on-command) for corrosion prevention.

DESCRIPTION: Corrosion of metal structures is estimated to cost many billions of dollars annually. The most common methods of corrosion inhibition or prevention involve the application of heavy surface treatments (paints and primers) or conversion coatings using various metallics that use application and removal techniques that are strictly controlled and regulated due to toxicity and possible carcinogenic properties. Hybrid polymers, such as ionic self-assembled monolayers (ISAMs), show promise as protective coating materials that offer opportunities for environmentally-friendly release-on-command" coating systems.The Air Force is seeking new coating systems that reduce the use of volatile organic compounds and hazardous material, such as hexavalent chromium, and offer unique release on command properties. The focus of this research is to meet the Air Force's top priority of corrosion protection, and environmental compliance for aircraft protection systems. The ISAMs are a recently developed [1,2] revolutionary technique that allows detailed structural control of materials at the molecular level combined with ease of manufacturing and low cost. A broad range of layer functionality is possible through incorporation of a wide range of inorganic nanoparticles to control of the electronic, conductive, optical, magnetic, thermal and mechanical properties. High-performance polymers may allow excellent thermal stability, mechanical properties as well as processability. New coating processes based on ISAMs and nanoparticles that: 1) offer corrosion inhibition on metal alloys without the use of chromium, 2) neither contains nor generates hazardous materials, 3) offer the potential for release-on-command capabilities, and 4) have demonstrated practical application methods including spraying and non-electrolytic brushing are of interest. Development activity should focus on corrosion protection for advanced fighter aircraft to address corrosion concerns with use of aluminum (7XXX series and emerging Al-Li airframe alloys), high-strength steel landing gear, and hybrid metal /graphite reinforced composite joints (e.g., Al substructure in contact with Gr/Ep and Gr/BMI skins). Such material combinations can be susceptible to galvanic induced corrosion/degradation modes. Protection of aluminum structure and metal/composite joints which are buried in corrosive environments in hard to access and/or inspect areas of the aircraft are of significant concern and must be addressed as a part of this effort.

PHASE I: Address the requirements and goals described above, and demonstrate the feasibility of the technology developed as proof of concept. Viability of the technology will be quantified in terms of the breadth of needs addressed and demonstration of corrosion prevention. The Phase I product for a successful effort is the formulation of the coating system, and testing and evaluation of this coating system on aluminum structures.

PHASE II: The product from Phase I would be developed through optimization and scale-up efforts to establish large-scale application and removal techniques of the corrosion inhibitor coating system. The product of this phase of the effort will need to be compatible with Air Force's current methods of aircraft inspection and maintenance.

PHASE III DUAL USE APPLICATIONS: The technology that will be produced under this effort has application in the protection of composite and metal structures against environmental degradation. Managing the structural health of expensive assets is of prime concern to all government services and commercial entities.

REFERENCES:

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KEYWORDS: corrosion protection, suppression, environmental damage management, coatings

AF02-115 TITLE: Superlattice Materials for Very-Long Wavelength Infrared Detectors (VLWIR)

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Research and development of innovative growth techniques and designs for semiconductor superlattices with narrow bandgaps

DESCRIPTION: The Air Force requires new very-long wavelength infrared (VLWIR) detectors with increased operating temperature, less than 40K in VLWIR, and improved detection for space-based applications. These detectors will be required to operate at wavelengths beyond 15 micrometers. The presently available detectors are based on extrinsic silicon. Due to excessive dark current, the operating temperature of these detectors is below 20K. The principle alternatives to extrinsic silicon at present are compound semiconductor superlattices based on III-V elements, such as antimonides and arsenides, or II-IV elements, such as tellurides. This task seeks to develop improved and innovative epitaxial growth techniques for growing superlattices based on novel semiconductor alloy combinations such as InGaSb/InAs, HgTe/CdTe or other promising materials. The key growth issues to be addressed are the interface purity, abruptness and repeated control of the individual superlattice layers, composition and thickness. Key design issues are optimized choices of superlattice layer compositions and thicknesses to achieve narrow band gaps with high IR absorption and low noise currents. Characterization of the superlattice electrical, optical or physical properties are also a major factor. Both molecular beam epitaxy (MBE) and metal organic chemical vapor deposition (MOCVD) will be considered as well as other novel growth techniques. Growth on novel substrates is encouraged.

PHASE I: Phase I will address growth and design of superlattices along with the minimum characterization to demonstrate that narrow bandgaps were achieved. A deliverable of a representative test sample to the government is encouraged.

PHASE II: Phase II will optimize the growth process and design demonstrated in Phase I with more extensive characterization and modeling as appropriate. Growth and evaluation of superlattice structures suitable for VLWIR detectors will be used to demonstrate the success of the program. Delivery of test materials to the government for evaluation is encouraged.

PHASE III DUAL USE APPLICATIONS: Structures based on semiconductor superlattices have applications in a wide variety of electronic and opto-electronic areas. Key devices with commercial markets would be room-temperature operating infrared detectors, infrared lasers and microwave transistors. The technical product from this effort is expected to be high-quality, heterostructure epitaxial materials. The commercial product can either be wafers of these materials designed to user needs, or devices fabricated from these materials.

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KEYWORDS: Infrared Detector, Semiconductor Materials, Superlattice, Very-Long Wavelength Infrared (VLWIR), Hetero-interfaces

AF02-116 TITLE: Conductive Resin Systems for Aircraft Composite Structures

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop a conductive polymeric resin matrix system that eliminates the requirement to secondarily apply conductive coatings to composite structures.

DESCRIPTION: Current advanced composites employ a structural fiber (fiberglass, carbon, kevlar, etc.) stabilized in a resin system. Current resin systems are very good dielectric materials i.e., they are non-conducting. This causes the manufacturers of composite aircraft concern. Electrical energy from sources such as a lightning strike can penetrate this dielectric film. In the case of fiberglass and kevlar, becasue they are nonconducting, electrical energy completely penetrates the fiber and enters the internal stucture creating structural damage. Airframe manufacturers can get around this by applying conducting coatings to these structures. However this is expensive, must be reapplied every time the paint is stripped from the aircraft, and causes EPA concerns from the standpoint of potentially releasing ozone depleting chemicals (ODCs) into the atmosphere and heavy metals into the waste stream.What is desired is a method to turn the dielectric film highly conductive to eliminate the use of these conductive coatings on the aircraft. The resulting product should minimize added weight and structural degradation while maximizing conductivity of the laminate into which it is introduced.

PHASE I: Demonstrate feasibility of an electrically conductive polymeric resin system in accordance with the requirements listed in the descriptive section. Material samples will be fabricated and analyzed. Electrical and mechanical property data will be provided from testing the samples.

PHASE II: Develop the conductive resin system and demonstrate the ability to manufacture panels employing the new resin system. Make panels, perform environmental testing to show stability of conductive materials and the amount of degradation to the mechanical properties of the laminates.

PHASE III DUAL USE APPLICATIONS: The Air Force has a variety of aircraft applications a successfully developed material would find use in. Commercial applications include electromagnetic interference (EMI) shielding and enhanced lightning damage suppression for structures.

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KEYWORDS: conductive polymer, conductive resin, dielectric material, lightning strike, conductive coatings, EMI shielding, conductive composite, polymer resin, structural resin

AF02-117 TITLE: Tamper Resistant Coating Development

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Identify a new tamper resistant coating (TRC) to protect electronic circuit boards used in secure communications and electronic equipment.

DESCRIPTION: The next generation of Air Force communications and electronics equipment require a TRC be applied to electronic components to protect sensitive hardware. In addition, there is increasing interest in antitamper technology in the Pentagon as evidenced by several recent memos from Dr. Gansler, Under Secretary of Defense for Acquisition and Technology. The current tamper resistant coating technology is based upon an expensive, thermal-

spray ceramic which results in lower than desired electrical yields of the delicate microelectronics being protected. There is an industry-wide need for a low-cost, high-reliability tamper-resistant coating that can be applied to multichip modules to protect not only the individual die, but also the interconnects. General requirements for a new TRC include:a. cannot degrade the performance of the cardb. cannot add cost or weight of more than 10 percentc. processing conditions cannot degrade the performance of the card (less than 175° C, no severe mechanical or vibratory stresses, no corrosive environments)d. can be used on existing circuit cards

PHASE I: 1) Identify alternate TRCs based upon lower temperature (less than 175° C) processing. The key requirements are a tough coating that, if removed, will catastrophically damage the underlying circuit board interconnects, traces, and or dies. 2) Evaluate these coatings for their affect on the underlying electronic reliability and demonstrate the material and process on a surrogate circuit board that demonstrates tamper resistance and operability of the underlying electronics.

PHASE II: 1) Develop a production-scalable process to implement the TRC technology identified in Phase I. 2) Evaluate this TRC for its ease of manufacture, affect upon circuit board materials/functional parameters (line widths, wire pitch, etc.). 3) Conduct long-term reliability testing of electronic circuit boards coated with the chosen TRC.

PHASE III DUAL USE APPLICATIONS: The TRCs developed for the Department of Defense are equally applicable for use on commercial microelectronics.

REFERENCES:

1. "Critical Infrastructure Protection: Presidential Decision Directive 63,", May 98, http://pccip.se-com.com.

2. "Cryptographic Hardware and Embedded Systems: 1st Internatinoal Workshop," CHES '99, Worchester, MA, Aug 12-13, 1999, G. Goos and Christof Paar (eds.)

KEYWORDS: Tamper, Resistant, Coating, Multichip Module, Microelectronics

AF02-118 TITLE: Secure Circuit Board Materials and Processes

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop secure, tamper resistant (TR) circuit board designs that would eliminate (or significantly reduce the reliance upon) the need for TR coatings.

DESCRIPTION: The next generation of Air Force communications and electronics equipment require a tamper-resistant coating (TRC) be applied to electronic components to protect sensitive hardware. In addition, there is increasing interest in antitamper technology in the Pentagon as evidenced by several recent memos from Dr. Gansler, Under Secretary of Defense for Acquisition and Technology. Current TR technology utilizes a tough coating that is expensive and results in lower than desired electrical yields of the delicate microelectronics being protected. There is an industry-wide need to develop new materials and processes for low-cost, high-reliability tamper-resistant circuit board construction. Recent advancements in composite materials and ordered polymers could lead to the design and construction of circuit boards that are inherently tamper resistant. General requirements for a new TR circuit board include:a. cannot degrade the performance over current circuit board designsb. cannot add cost or weight of more than 10 percentc. processing conditions cannot degrade the performance of the card (i.e. less than 175° C, no severe mechanical or vibratory stresses, no corrosive environments)

PHASE I: 1) Explore circuit board construction materials to include imbedded trace and die design, improved interconnect design, and alternate packaging such as encapsulation. Encapsulation techniques could be used on existing boards but new construction approaches would have to be used on new board designs. 2) Evaluate a new circuit board construction design for its underlying electronic reliability and demonstrate the materials and processes on a surrogate circuit board that demonstrates tamper resistance and operability of the electronics.

PHASE II: 1) Develop a production-scalable process to implement the TR circuit board construction technology identified in Phase I. 2) Evaluate this construction approach for ease of manufacture, and its effect upon circuit board materials/functional parameters (line widths, wire pitch, etc.). 3) Conduct long-term reliability testing of electronic circuit boards.

PHASE III DUAL USE APPLICATIONS: Tamper-resistant/security-protected technology has both Department of Defense and commercial applications in the future for global positioning systems.

REFERENCES:
1. "Critical Infrastructure Protection: Presidential Decision Directive 63", May 98, http://pccip.se-com.com

2. Cryptographic Hardware and Embedded Systems: 1st Internatinoal Workshop, CHES '99, Worchester, MA, August 12-13, 1999, G. Goos and Christof Paar (eds.).

KEYWORDS: Tamper, Resistant, Circuit Board, Composite, Ordered Polymers, Multichip Module, Microelectronics

AF02-119 TITLE: Tailored Adhesives for Damage Tolerant Joints

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Improve the integrity and reliability of aerospace-grade adhesives in bonded joints increasing ballistic survivability and allowing reduction of fasteners with subsequent savings in cost and weight.

DESCRIPTION: Bonded joints have been shown to have adequate strength and integrity to eliminate fasteners in most joints, however, in wet wings there is still an issue with ballistic survivability because of hydrodynamic ram stresses. One technique that has been shown to alleviate this problem is z-pinning of the joints with a reinforcement of transverse carbon or titanium pins. This technique adds considerable expense to the manufacturing process and the diameters of the pins are such that they distort and break fibers locally during insertion, reducing their effectiveness.Aerospace-grade epoxy adhesives used in both original component fabrication and repair applications can have various forms of carrier materials, each of which can have a dramatic effect on adhesively-bonded joint strength and durability. The carrier cloths are available in either random mat, knit woven or square patterns in dacron, nylon or glass fabrics. Carrier cloths are placed in film adhesives during manufacture mainly for handling control during subsequent part fabrication; however, they also provide bondline thickness control of a cured bonded joint. The adhesive supported with the knit woven carrier gives the highest stiffness while the random mat provides superior handling characteristics. Several efforts have been conducted to demonstrate the impact of the scrim in an adhesive on the static, fatigue, and mechanical properties of a bonded joint. The additions of low fiber volume scrim materials (graphite, Kevlar and Boron) have shown dramatic improvement in fatigue properties. The problem with continuous fibers is the resistance to out-of-plane loading. A few efforts have investigated discontinuous reinforcement in an adhesive (graphite flakes and silicon carbide whiskers), which can offer z-axis reinforcement.

PHASE I: Address the goals and requirements discussed above and demonstrate the viability and potential to develop an inexpensive method for including translaminar reinforcement into adhesives and to apply it to joints in such a way as to make the reinforcement connect the adherends. The success of the Phase I effort will be determined by the ability to deliver small quantities of sample material, and the obtainment of corresponding mechanical property data as a proof of concept.

PHASE II: Develop the adhesive system and demonstrate the ability to manufacture subcoupons employing the new system. Make panels, perform environmental testing to show stability of mechanical joints and the amount of degradation to the mechanical properties of the laminates.

PHASE III DUAL USE APPLICATIONS: The Air Force has a variety of aircraft applications, a successfully developed material would find use in. Commercial applications include electromagnetic interference (EMI) shielding and enhanced lightning suppression for structures.

REFERENCES:
1. Forte, M.S., "A Controlled Study of the Effects of Bondline Reinforcement On the Fracture Behavior of a Brittle Epoxy Adhesive," Ph.D. Dissertation, University of Dayton, May 1999

2. Forte, M.S., Whitney, J.M., and Schoeppner, G.A., "Influence of Adhesive Reinforcement on the Mode I Fracture Toughness of a Bonded Joint," Composites Science and Technology, Vol. 60, No. 12-13, September 2000, pp. 2389-2405.

3. Kuhbander, R.J., and Aponyi, T.J., "New Concepts in Fatigue Resistant Adhesives," Proceedings of the Twentieth National Symposium and Exhibition, San Diego, Ca, April 29 - May 1, 1975, San Diego, CA, pp 589-605.

4. "Exploratory Development of Improved Fatigue Strength Adhesives," The Dexter Corporation, AFML-TR-74-169, ADB009505, Air Force Materials Laboratory, November 1974.

5. "Improved Fatigue Strength Adhesive Part II - Adhesive Optimization," The Dexter Corporation, AFML-TR-74-169 Part 2, ADB009505, Air Force Materials Laboratory, December 1975.

KEYWORDS: adhesives, bonded joints, bondline reinforcement, scrim

AF02-120 TITLE: Qualifying Light, High-Performance Materials for Airborne Expeditionary Forces (AEF)

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop a rapid materials-selection strategy and demonostrate efficiency on critical high-energy laser components and vehicle structures.

DESCRIPTION: The Airborne Laser (ABL) weapon system, based on the chemical-oxygen-iodine laser (COIL) concept, represents a major advancement in weapon system technology. The unique chemistry of a COIL presents new challenges in chemical processing, material handling, process material selection, logistics, and safety. Airborne laser and space-based chemical laser systems require lightweight, high-performance materials to achieve system performance objectives. The chemicals used in chemically-driven laser systems are incompatible with many materials used in aircraft, spacecraft and the chemical processing industry. In addition, materials that have been used for ground-based chemical laser systems pose extreme weight penalties for aircraft and space applications. Conventional material evaluation techniques require long test periods and are labor intensive. The objective of this project is to develop rapid, high-confidence, materials selection/evaluation techniques to predict material performance for critical aircraft/spacecraft laser systems, in a compressed amount of time.

PHASE I: Perform comprehensive materials testing/evaluation strategy studies, involving the use of subscale process elements, representative of full-scale operational equipment, intended for the use on high-energy chemical laser systems. Chemical exposure duration of as much as 3,000 hrs is required with intermittent material assessment. Phase I activity should include (among other activities): (1) material selection (to include coating systems), fabrication, and identification (government and contractor specified), (2) performance evaluation criteria, (3) material performance data correlated to system design (size, weight, process fluid interactions) and operation (reliability, availability, maintainability) and (4) material performance data correlated to equipment service decisions (mission capable, nonmission capable, mission capable with waiver).

PHASE II: Demonstrate rapid material qualification on selected process materials for COIL systems and weapon system vehicle structures. Provide equipment failure modes, assessment techniques for full-scale system evaluation, and mean-time-between-failure for system critical components. Phase II demonstrations should include: (1) identification and qualification of materials and material suppliers, (2) test configuration and chemical exposure, (3) subscale test component fabrication, and (4) post-exposure material inspection, analysis, and qualification. The strategy and demonstration should be an iterative process based on statistical experimental design that will result in the greatest amount of information in the shortest amount of time. Materials should be selected that will result in decision alternatives: i.e. plan B, C, etc., should any selected materials fail to meet performance criteria. Process materials must be suitable for use in systems exposed to basic hydrogen peroxide, chlorine gas, chlorine liquid, hydrogen peroxide (70-wt. %), and ammonia (anhydrous). Specific conditions can be provided upon request.

PHASE III DUAL USE APPLICATIONS: The procedures and methods developed in this effort will compress significantly the development time for advanced chemical-based weapon systems by reducing the time for selecting and qualifying new materials and new material applications. Air Force weapon systems of the future require new methods and tools for managing programmatic and technical risk such as the one specified herein. In addition, developments in this area will be of value in other process industries, such as production of polymeric materials and manufacturing that requires rapid prototyping. It is expected such applications will an abundance of applications in the commercial and defense sectors.

REFERENCES:
1. Oxygen-Iodine Supersonic Technology Program, Area I Supersonic Laser, Subsystem Design Analysis Report, October 13, 1983, Unclassified, TRW Space and Technology Group, Redondo Beach, CA 90278, Contract Number F29601-82-C-0083.

KEYWORDS: Chemical-Oxygen-Iodine Laser (COIL), Material evaluation techniques, Basic hydrogen peroxide, Iterative process, Chemical decomposition, Statistical experimentalDesign, Airborne/Space-Based Chemical Laser

AF02-121 TITLE: Use of Alternate Materials for Infrared (IR) Missile Domes

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: To develop lower cost processing of missile domes and investigate alternate materials to sapphire which have already shown manufacturing potential, but require additional characterization to be acceptable for high speed missile applications.

DESCRIPTION: Sapphire, with its high strength and hardness, is the material selected for many infrared (IR) missiles domes due to the extreme environments encountered during flight. Although sapphire meets all the performance requirements, it is also one of the high-cost items in the total system. Sapphire is grown as boules from the melt and is expensive due to the waste following fabrication and the extensive polishing required due to its hardness. The current cost of a sapphire IR missile dome is $1800 to $2700 and generally is procured from one vendor. Thus, a different material is needed that has a flexible process resulting in lower cost missile domes. Additional process development would be expected to demonstrate a more affordable product than sapphire. Alternate materials to sapphire (in the 3-5 micron range) would include, but not be limited to, aluminum oxynitride (ALON), spinel, and MgF2. These materials appear to have similar materials properties with sapphire; however, have not been proven in extreme environments that are encountered during flyout. Some of the more critical properties include compressive strength tests to simulate thermal shock and durability tests (rain and sand erosion). This effort will investigate alternate materials to sapphire that are easier to manufacture, thus will be less expensive to produce and fabricate into 3-inch IR missile domes.

PHASE I: Phase I will identify candidate midwave materials that are comparable to sapphire and can withstand the environments and performance requirements of IR missiles systems. Additionally, these candidates must possess flexibility in the manufacturing process and have qualities as described above. Currently, MgF2 is the baseline, thus any candidate must meet, at a minimum, the performance properties of MgF2 for thermal shock and durability to be considered. This phase may include modeling analysis on the candidate materials for screening purposes and to determine the thermal shock performance at elevated temperatures. A candidate material will be selected for testing. This testing would include, as a minimum, durability tests. Results from this testing will demonstrate the feasibility of at least one potential replacement for sapphire in IR missile dome applications.

PHASE II: Further development of the chosen material and processing methods will occur. The processing method will be analyzed to identify steps in the process that could be improved to result in a more affordable and efficient manufacturing process. Some trial runs are anticipated to test the potential improvements. The material will then be fabricated into prototype domes utilizing the improved process and tested to verify the overall performance and manufacturing efficiency. The critical test will be a compressive strength test that simulates thermal shock to the dome at a peak temperature of 450 degrees Centigrade. Based on the results, a performance comparison would be made to sapphire which would include manufacturability of the alternate material at the system level. A cost estimate will also be conducted to project actual production cost of 600 domes/year to a projected 10,000 overall. The desired outcome of this phase is twofold: a material that can be submitted for qualification as an alternate missile dome material and a new manufacturing process that could be licensed or patented

PHASE III DUAL USE APPLICATIONS: The alternate material identified would be a potential replacement in other sapphire applications beside missile domes. It is anticipated that a proprietary process will be developed that is improved and most cost-effective. A small business should be able to license or patent this new process. Military applications - Sapphire has excellent optical properties and provides great durability, thus it is used for IR windows. These windows tend to be flat, and the alternate material could be a utilized for IR window applications. Scale-up to larger (size) missile domes. Due to its rigidity, sapphire also provides good ballistic impact resistance, a very desirable property in transparent armor, which would be another military application. b. Commercial application - Sapphire is used in supermarket scanners, usually as a thin layer over glass, because of its hardness and scratch resistance. It is not formed into a solid scanner window due it being cost prohibitive, so it is applied as a thin layer over glass. The alternate material would be fabricated into a flat, solid piece and could replace the sapphire-glass laminate.

REFERENCES:

1. T.M. Hartnett and R.L. Gentilmen, "Optical and Mechanical Properties of Highly Transparent Spinel and ALON Domes," SPIE Proc. Vol. 505 (1984) 15.

2. P.C. Archibald and D.K. Burge, "Optical Measurements on Advanced Performance Domes," SPIE Proc. Vol. 505 (1984) 52.

3. E.A. Maguire, J.K. Rawson, and R.W. Tustison, "Aluminum Oxynitride's Resistance to Impact and Erosion, SPIE Proc. Vol 2286, (1994) 26.

KEYWORDS: sapphire, missile domes, aluminum oxynitride (ALON), spinel, magnesium fluoride, thermal shock, midwave materials

AF02-122 TITLE: Individual Plastic Component Water Sealing

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop material and process to prevent moisture absorption by plastic parts at the component level during storage prior to use in building next-level assembly, during storage as spares, storage of higher level assemblies, and while in operational use.

DESCRIPTION: Due to both cost and availability of traditional space and military-grade parts, modern missile systems are being forced to use commercial electronic components including plastic encapsulated microcircuits (PEM). Many types of commercial parts are not capable of performing in the harsh external environments required for military and space applications. One environmental problem when using PEM devices in space or high-altitude applications is moisture being absorbed into the encapsulant material prior to launch and changing to gas phase when taken to high altitude. The expansion that occurs when moisture changes to gas phase can crack the part case and cause electrical failure. Bursting PEM cases in this way has been dubbed popcorning. To prevent popcorning at altitude, the current design practice is to include an elaborate sealed chassis and/or desiccant, and conformal coating at the board level. There is considerable evidence that none of these measures prevents organic materials, including PEM packages, from becoming saturated when exposed over time to moisture. Traditional organic conformal coating materials, used at the board level, will obviously not work as a component-level moisture barrier. Therefore, a breakthrough is required in development of an effective moisture barrier for commercial-grade parts.In addition, an effective moisture-control measure must keep water content of device packages to acceptable levels during storage of flight hardware of both assembly and component-level spares. Effective measures must be taken in order to meet the demand for longer warrantees and requirements for a low maintenance burden. Stringent sealing, desiccation, and some conformal coating would not be required if a process was available that prevented moisture absorption at the component level. If enclosure-level moisture proofing was not necessary, electronic housings could be smaller, lighter, and less costly. Reliability would no longer depend on sealed chassis design and/or workmanship of hand-applied sealants.The situation is exacerbated by the need to use commercial parts as replacements for logistic repairs. Without adequate moisture control during storage of PEM devices prior to use as a repair part, there is a higher risk of popcorn failures following a repair. In addition, an acceptable PEM coating must be capable of withstanding the thermal and chemical stresses inherent in the board-level manufacturing and logistic repair environments, as well as, test environments at the part, board and box levels, and still provide a demonstrated effective moisture barrier.Today's military customer favors a solution that eliminates moisture sensitivity at the part and material level, and allows the use of lower weight, less-expensive enclosures for avionics assemblies.

PHASE I: Determine various materials and techniques that could be applied to the exterior of these components that would prevent moisture absorption.

PHASE II: Perform lab evaluations of the candidate materials and processes identified in Phase 1. This would include exposure to simulated external environments and pressures. Down select to a limited set of viable candidates.

PHASE III DUAL USE APPLICATIONS: Assemble a series of production electronic subassemblies using the candidate that is representative of various applications, such as power and signal processing. Perform qualification-level functional and performance tests under specified environments that include increases in levels that would demonstrate durability.

REFERENCES:

KEYWORDS: popcorning, plastic encapsulated microcircuits (PEM), integrated circuit, microcircuit, moisture barrier, coating, sealing

AF02-123 TITLE: Innovative Approaches in Secure Hardware

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Identify new materials and processing technologies for the fabrication of tamper-resistant circuit boards.

DESCRIPTION: The next generation of Air Force communications and electonics equipment require tamper-resistant coatings and other methods applied to electronic components to protect sensitive hardware. In addition, there is increasing interest in antitamper technology in the Pentagon as evidenced by several recent memos from Dr. Gansler, Under Secretary of Defense for Acquisition and Technology. Current tamper-resistant circuit board designs involve a variety of special coatings and treatments for both board and components. The utilization of emerging materials technologies to construct circuit boards that are inherently tamper resistant would improve the reliability and reduce cost and weight of electronic components. Self-assembled monolayers of conductive, semiconductive, and insulative molecules could be used to construct cards with no discernable construction. Advanced composite laminate construction techniques could produce multifunctional circuit boards with electronic packaging and tamper resistance functions. Other innovative materials and processing techniques that could be applied to secure circuit board design are also welcome. Secure materials and processing techniques should impart solvent, acid, and physical attack (drilling, sawing, etc.) resistance such that any attack damages the underlying circuit board components rendering the components useless.

PHASE I: 1) Define shortcomings in current circuit board construction and design that could be overcome with advanced materials and processing technologies 2) Identify promising materials technologies than could lead to improved circuit board designs. 3) Characterize promising constructions for processability and electrical performance. 4) Prepare specimens for the demonstration of key material attributes.

PHASE II: 1) Identify a baseline prototype circuit card design for demonstration of the materials technologies identified in Phase I. 2) Fabricate a demonstration circuit card for evaluation by the Air Force.

PHASE III DUAL USE APPLICATIONS: Tamper-resistant components developed for the Department of Defense are equally applicable for use on commercial microelectronics.

REFERENCES:
1. "Critical Infrastructure Protection: Presidential Decision Directive 63", May 98, http://pccip.se-com.com.

2. Cryptographic Hardware and Embedded Systems: 1st Internatinoal Workshop, CHES '99, Worchester, MA, August 12-13, 1999, G. Goos and Christof Paar (eds.).

3. DoD Department of Defense Directive Number 5200.30; Subject: Security, Intelligence, and Counterintelligence Support to Acquisition Program Protection.

KEYWORDS: Tamper, Resistant, Coating, Multichip Module, Microelectronics

AF02-124 TITLE: Demonstration of Compound Semiconductor Films on a Compliant Substrate

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Demonstrate the application of a compound semiconductor thin film on a silicon-based compliant substrate.

DESCRIPTION: Compound semiconductors offer a variety of material properties that enhance the performance of microelectronic devices, such as solar cells, infrared (IR) detectors, microwave devices, and optoelectronic integrated circuits, over that provided by the more common elemental semiconductors, silicon and germanium. It has been difficult to commercialize such compound semiconductor devices because of the high cost and relatively poor quality of the starting material. Recent success in transferring ultrathin compound semiconductor films to a silicon handle wafer offers the opportunity to significantly reduce the cost of these types of devices. Although it is anticipated that these new starting silicon wafers will also result in improvements in device performance, yield, and reliability, problems with achieving these benefits have yet to be identified and solved. Certainly, accommodating stress associated with the thermal mismatch between materials (silicon wafer/compound semiconductor), dealing with defects in the compound semiconductor device film, as well as at the interface between the device film and the wafer substrate are anticipated challenges. Therefore, the purpose of this project, therefore, is to demonstrate the application of a

candidate compound semiconductor device to these new silicon starting wafers. The processing and inspection techniques that will be needed to put the resulting new materials into production should be identified and developed.

PHASE I: Phase I: Demonstrate the feasibility of a primary substrate material in terms of device performance, yield, and reliability. Identify any problems that may need to be addressed in a Phase II effort. Modeling and simulation may be useful in guiding the development of the chosen processing approach.

PHASE II: Phase II: Further develop the processing approach demonstrated during the Phase I effort. Prototype the proposed candidate (compound semiconductor wafer) device and substrate system. Quantify the advantages of the prototype device/substrate system with appropriate electrical, chemical, optical, and structural analyses. Develop a commercialization strategy to transition the prototype system to industry.

PHASE III DUAL USE APPLICATIONS: Any of the types of devices anticipated to be selected as prototypes in this program are expected to be of interest for both commercial and military applications. The potential advantages offered by the new starting wafers; (increased performance/lower cost microelectronic devices), would make the resulting devices attractive for dual use applications.

REFERENCES:

1. Ejeckam, F. E., et al., "Dislocation-free InSb Grown on GaAs Compliant Universal Substrates," Appl. Phys. Lett., 71(6), p. 776, August 11, 1997

2. Fathimulla, A., et al., "Growth and Fabrication of InGaAs/InAlAs HEMTs on Bonded-and-etch-back InP-on-Si," Second Int'l Conf. On Indium Phosphide and Related Materials, Denver, CO, p. 57, 1990.

3. Steckl, A. J., et al., "The Growth and Characterization of GaN thin films on SiC SOI Substrates," J. of Electronic Mat'ls, 26(3), p. 217, March 1997.

KEYWORDS: Compound Semiconductors, Compliant Substrate, Thin Film Devices, Microelectronics, Solar Cells, Detectors

AF02-125 TITLE: Crack Growth Behavior of Hard Alpha Inclusions in Titanium Castings

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: The objective of this research topic is to characterize the fatigue crack propagation characteristics of hard alpha inclusions in 6Al-4V titanium castings. Product will be an analytical tool to use for crack growth analysis of hard alpha defects in cast titanium airframe structure.This product is transitionable to military and commercial users of titanium castings.

DESCRIPTION: Hard alpha inclusions are defects that can occur in titanium castings from contamination in the casting process and are brittle in nature. To date, these defects have been analyzed as cracks, since little data has been developed on their behavior under loading. However, this approach may be overly conservative and result in designs being overweight or place an increased inspection burden on fielded aircraft. Data developed on fatigue crack propagation from within these defects can be used to more accurately assess impacts on structural life. This topic seeks proposals for innovative approaches to characterizing fatigue crack initiation at hard alpha inclusions within Ti 6Al-4V titanium castings.

PHASE I: Perform feasibility study to determine usefulness to major airframe designers of an analytical tool to account for hard alpha defects. Onsite visits with airframe vendors will be required to understand nature of hard alpha problem.

PHASE II: a. Prepare specimens of cast material with embedded hard alpha inclusions. An attempt shall be made to vary hard alpha size as well as associated interstitial diffusion zone ("halo").b. Perform constant amplitude fatigue testing, measuring small crack-growth during test.

PHASE III DUAL USE APPLICATIONS: a. Perform destructive analysis on specimens to measure actual hard alpha and halo sizes.b. Determine equivalent initial flaw size to be assumed for crack growth analyses.c. Transition analytical tool to users for design of cast titanium airframe structure.

REFERENCES:

J.D. Cotton, L.P. Clark, T.R. Reinhart, W.S. Spear, S.J. Veeck and G.R. Strabel, "Inclusions in Ti-6Al-4V Investment Castings," Paper #AIAA-2000-1464, 41st AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference & Exhibit, 3-6 April 2000, Atlanta, GA.

KEYWORDS: hard alpha inclusionfatiguecastingtitanium

AF02-126 TITLE: Verification of Composite Bonded Joint Integrity

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: To develop an inspection technology to verify load-carrying capability of bonded joints.

DESCRIPTION: Standard nondestructive inspection techniques can identify, within limits, porosity and disbonds within bonded joints. Identification of bondline defects is a necessary but not sufficient condition for assurance of bond integrity. For instance, weak bonds may exist due to improper adhesive cure, inadequate surface preparation, contamination of the adherands, or insufficient pressure during the cure cycle. Additionally, environmental durability of bonded joints is strongly influenced by the prebond preparation of the mating surfaces. Some of the current research efforts in this area utilize embedded sensors to verify load-carrying capability. Depending upon their size and location, these sensors may be considered defects in the laminate or bondline and must be accounted for in the design process. This effort seeks to develop a technique to interrogate a bonded joint in completed composite structures to determine if the area in question is capable of carrying at least a minimum load. The technique may be utilized to determine initial bond load-carrying capability. If possible, it is desired that the developed technology be capable of providing data regarding a minimum load-carrying capability of the bonded joint throughout its service life. Attempts to estimate the strength of an adhesive bond via a number of nondestructive measurements have been completely unsuccessful. Because there is no reason to expect any breakthrough in this area from a fundamental scientific standpoint, this program is encouraging other novel approaches to the examination of the load-bearing capability of an adhesive bond. For review of previous work the reader is referred to the review articles listed below.

PHASE I: Efforts should focus on developing an NDI solution which does not create a bondline defect in and of itself. The proposed solution should be able to evaluate load-bearing capability at any stage of the bond's existence, i.e., initial or aged. The proposed solution should also consider unit cost to be paramount. The proposed approach must not take the route of previous failed attempts to provide the solution using ultrasonic methods.

PHASE II: Develop a prototype device and demonstrate its capability on both a repaired bondline (initial and aged) and an aged bond which has not been repaired but which has been aged an amount that simulates a field exposure of mutually agreed upon time.

PHASE III DUAL USE APPLICATIONS: Instrumentation will be produced that is applicable to both military and civilian bonding applications. For this phase of the program additional resources beyond that available from government funding must be acquired. The may be either angel or venture capital funds. These additional resources should provide sufficient resources to produce working devices that have wide applicability to both military and civilian marketplace.

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1. Adams, R. D., Cawley, P. and Guyott, C. C. H., "Non-Destructive Testing of Adhesive Joints," 23rd Annual Conference on Adhesion and Ahesives, London, England, Adhesion 10, p. 96-112, Elsevier Applied Science Publishers Ltd, London (1986).

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3. Dukes, W. A. and Kinloch, A. J., "Non-Destructive Testing of Bonded Joints - an Adhesion Science Viewpoint," Non-Destructive Testing, Vol. 7, No. 6, p. 324-326 (1974).

4. Hagemaier, D. and Fassbender, R., "Nondestructive Testing of Adhesive Bonded Structures," SAMPE Quarterly, Vol. 9, No. 4, p. 36-58 (1978).

5. Hart-Smith, L. J., "Reliable Nondestructive Inspection of Adhesively Bonded Metallic Structures Without Any Instruments," Materials Challenge: Diversification and the Future, Vol. 40-II, p. 1124-1133, Society for the Advancement of Material and Process Engineering, Atlanta, GA (1995)

KEYWORDS: nondestructive investigation, embedded sensors, bondline defects.

AF02-128 TITLE: Logistic Fuel Sulfur Removal for Fuel Cell Use in Air Expeditionary Force (AEF) Operations

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Demonstrate the feasibility of developing and optimizing an innovative, highly efficient, and miniaturized sulfur removal technology suitable for fuel cell use in AEF operations.

DESCRIPTION: The rapid evolution of fuel cell technology as a replacement for conventional electric power generators has provided a gateway to future efficient and reliable power generating systems using hydrogen as primary fuel. The major drawback to the use of fuel cells as electric generators for deployed forces is the inability to effectively use battlefield fuels (diesel and JP-8) as the primary energy source. The ability to use fuel cell requires the removal of sulfur to ultralow levels from logistic fuel before reforming the fuel to hydrogen. Sulfur content in fuel can reach 700 ppm. Conventional hydrotreating technologies require hydrogen feed as well as high-temperature and high-pressure reactors to produce low sulfur diesel, which results in higher capital requirements and excessive operating costs. Current state-of-the-art sulfur reduction technology developed by Phillips Petroleum, uses a regenerable sorbent that chemically attracts sulfur and removes it from hydrocarbon streams. The hydrogen feed requirement makes these technologies unattractive for military deployment missions. A new sulfur removal technology that operates at low pressure, is compact, efficient, requires no hydrogen feed with sorbent materia, andl that can be regenerated while the unit is operating is sought.

PHASE I: Demonstrate the feasibility of a sulfur removal technology using a laboratory scale reactor that reaches close to 100 percent removal efficiency.

PHASE II: Fabricate and demonstrate a 2 kilogram per hour fuel mass flow rate sulfur removal system.

PHASE III DUAL USE APPLICATIONS: A successful development of an efficient sulfur removal will have a multitude of commercial applications in addition to the bare-base fuel cell power generation. With the EPA requirement for super-low sulfur content in gasoline and diesel fuels, efficient and compact sulfur removal technology will have a great impact on the refinery industries.

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KEYWORDS: sulfur removal, logistic fuel reformer, fuel processor, fuel cell

AF02-129 TITLE: Advanced Materials for Lightweight Space-Based Mirrors

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop innovative methods and materials (polymers, metals, ceramics, and their associated composites [e.g. fiberous, particulate, foams, etc.]) for manufacturing cost-effective, large, deployable, lightweight mirrors for airborne and space-based applications in the visible range.

DESCRIPTION: The Air Force (AF) is seeking new and highly innovative concepts for affordable space-based mirrors. Traditional mirrors are often very expensive and time consuming to produce. They are also generally quite heavy. These mirrors are generally machined to a rough figure from a relatively heavy blank of material, requiring extensive capital investment in machining capabilities and machining time. The mirrors are then finally figured using a variety of grinding and polishing techniques that can also be extremely expensive and time consuming. In addition to reducing the cost and time required to produce primary mirrors, reducing the areal density of a primary imaging or beam converging mirrors is critical to the deployment of future AF platforms, e.g., space-based laser. Desired material characteristics include low density, high stiffness, near-zero coefficient of thermal expansion (CTE) in the operational range, high thermal conductivity, and high fracture toughness for vibration, impact, and heat-load damage control.

These properties, along with innovative processing methodologies, can be manipulated to allow a significant reduction in the mass and cost of primary mirror structures. Innovative methodologies and materials for the manufacture of lightweight, near net shaped, large, cost-effective primary mirror systems are sought.

PHASE I: Demonstrate feasibility of a material system, design approach, and associated manufacturing processes in order to optimize cost effectiveness and reduce areal density while maintaining performance. Develop performance estimates in terms of mass, cost, and appropriate mirror performance parameters. Fabricate proof-of-concept coupon/subelement components and develop/specify test methods necessary to aid in performance estimation. Suggest iterations to the design and manufacturing methodology to improve the manufacturing cost, scalability, and areal density without sacrificing performance.

PHASE II: Demonstrate the manufacturing and test methodologies suggested in Phase I on a subelement basis so that a down selection to an optimum design is possible. Demonstrate the capability of the material and process developed in Phase II by fabricating at least a 1-meter diameter primary mirror. Quantify the cost and performance of the mirror with respect to the estimated parameters from Phase I. Produce a plan for demonstrating reproducibility and reliability of the 1-meter mirror manufacturing process and for scaling to larger mirrors or mirror segments.

PHASE III DUAL USE APPLICATIONS: Primary imaging and beam converging mirrors have application on a variety of DoD and commercial spacecraft. Traditional mirror designs are heavy and costly. Demonstration of a lightweight, large, lower cost alternative would provide tremendous savings and capability enhancement for future spacecraft requiring these types of mirrors.

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KEYWORDS: adaptive optics, atmospheric compensation, micromachining, deformable mirror, space based laser wavefront control, cost effective, survivability, reliability, segmented mirrors

AF02-130 TITLE: Dynamic Filtering of MidWave InfraRed (MWIR) Radiation

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop materials and concepts for dynamic filtering of MWIR radiation.

DESCRIPTION: The continued growth of optical applications and devices outside visible and communication wavelengths has resulted in a need for optical control elements in these wavelength regions. One particular area of interest is the MWIR (2 to 5 mm) spectral region. The ability to dynamically filter information on millisecond or faster time scales and with high fidelity is the goal. The Air Force solicits new materials and devices for the controlled attenuation of light in this spectral region. Desired material characteristics include large contrast ratio, fast speed, and high transmission.

PHASE I: Demonstrate the feasibility of new materials and approaches for high fidelity filtering in this spectral band.

PHASE II: Develop the approach chosen and fully demonsrate its usefulness for commercial and military applications.

PHASE III DUAL USE APPLICATIONS: MWIR radiation is employed in a variety of industrial, medical and environmental applications for materials processing, inspection, diagnostics or chemical sensing. Agile and fast tunable filters developed in this program would have broad commercial applications in the MWIR systems as optical shutters, switches, filters and fiber-optic components. They would also have a wide variety of dual defense/commercial applications as solid-state components for multi/hyperspectral imagery in airborne and space-based sensing platforms.

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KEYWORDS: midwave infrared (MWIR), filters, switches

AF02-131 TITLE: Novel Materials for Spacecraft Thermal Control Coatings Technologies

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: To identify and develop novel materials (e.g., nanoparticles, conductive particles) for very low solar absorptance and /or tunable emittance in spacecraft thermal control coatings. The new coating system will provide 15 to 20 years in-service thermal management in mid-earth to geosynchronous environment.

DESCRIPTION: Space assets inhabit a harsh thermal environment in which the high intensity of direct solar radiation can raise spacecraft temperatures to potentially dangerous levels. Thus, some method of thermal control is required for hardware to reduce the absorption of solar radiation, as well as dissipate internal heat to proper levels. Temperature control on current spacecraft is achieved using thermal control coatings on radiators.Current state-of-the-art thermal control coating technology uses a potassium silicate binder with a zinc oxide pigment. While there are several variants of this coating system presently in use, this technology has not changed much since the late 1960's when it was first developed. The resultant white coating has a typical beginning-of-life solar absorptance value between 0.15 and 0.20, and beginning-of-life emittance value greater than 0.80. However, after approximately 5-7 years in-service the typical solar absorptance value has degraded to greater than 0.40. As the sizing of spacecraft is done to the end-of-life properties, a much larger vehicle is needed to accommodate this deterioration. This is contrary to the Air Force's need to have smaller, lighter weight space vehicles in the 21st century that have in-service lifetimes of 15-20 years. Thus, revolutionary new materials that maintain their optical properties in service are essential to achieving these objectives.

PHASE I: Demonstrate the feasibility of a new thermal control coating for use in mid-earth to geosynchronous orbits that has the potential of improving the performance parameters mentioned in the description. Specifically, the thermal control coating(s) developed in Phase I will need to be shown to be capable of meeting an inital solar absorptance (as) value of less than 0.15 (threshold), and preferably be less than 0.10 (objective). For a passive coating (without tunable emittance), both the threshold and objective emittance values shall be greater than 0.80. The potential coating(s) will need to be shown not to exceed a 50% increase in solar absorptance after an exposure of 2000 equivalent sun hours to ultraviolet radiation. For an active system, it will need to be shown that the tunable emittance values can be varied between 0.20 - 0.80 after an exposure of 2000 equivalent sun hours of ultraviolet radiation. In addition, stability to electron, and proton environments will need to be demonstrated.

PHASE II: Further develop the proposed coating system. Simulated space flight experimental tests will be conducted on the coating to establish performance parameters, including durability. The new coating will also be flown/tested on an actual space flight experiment when there is an available mission.

PHASE III DUAL USE APPLICATIONS: The final coating system will have application that includes both commercial and military space satellites, vehicles, and platforms that are in mid-earth to geosynchronous orbits.

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KEYWORDS: geosynchronous environment, space environmental effects, ultraviolet radiation, proton radiation, electron radiation, degradation mechanisms, thermal vacuum, thermal control coating(s), spacecraft coating(s), thermal management

AF02-132 TITLE: Polymer Claddings for Space Photonics

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop optimized cladding layers for polymer-based photonic devices.

DESCRIPTION: Photonics makes possible secure, high-bandwidth data links, and advanced data handling architectures for satellites while at the same time offering significantly reduced susceptibility to electromagnetic pulse interference, reduced radar cross-section, and reduced electromagnetic noise generation. Polymer-based photonics, in particular, provides additional advantages for space-based applications over devices based upon the state-of-the-art photonic material, lithium niobate. These are a higher tolerance against space radiation effects, reduced operating voltages, smaller device size, an ability to directly integrate with electronics, improved temporal and thermal stability, no piezoelectric ringing, higher frequency performance, and reduced operating power. However, one of the primary limitations to polymer-based photonics for optical modulators and routers has been a compatible cladding layer. Air Force patented technology has previously enabled the highest performance optical modulators by incorporating conducting cladding layers in the devices. However, cladding layers must be further developed for practical devices by optimizing their conductivity, dielectric constant, optical loss, chemical compatibility, and mechanical properties with respect to the electro-optic polymer core layer. Therefore, the objective of this effort is to develop compatible cladding layers for fabricating optical modulators with a high frequency cutoff (greater than 100GHz), an extremely low switching voltage (Vpi near 0.3 volt), low optical waveguide loss (less than 1dB/cm), high thermal stability (125 C operating temperature), temporal stability, and high radiation tolerance. The operating laser wavelength is 1550 nm. Optical waveguide devices may be fabricated only as an integral part of a materials development effort to evaluate and demonstrate the properties of the material(s).

PHASE I: Demonstrate a new material, the feasibility of a proposed new growth technique, improved functionality of a material through innovative processing techniques, or improved materials properties resulting from either growth or processing advancements.

PHASE II: Further develop the proposed material and/or the relevant processes to fully demonstrate the materials properties and usefulness for commercial and military applications. Establish all necessary manufacturing processes for commercialization of a product.

PHASE III DUAL USE APPLICATIONS: Materials technology is fundamental to all applications, military and commercial. Examples of commercial applications are optical switches for cable TV, optical phase shifters for phased-array radar, optical interconnects for electronic packages, and switching networks for optical communications.

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KEYWORDS: optical modulators, optical waveguides, photonics

AF02-133 TITLE: Multifunctional Thermally and Electrically Conductive Carbon Nanotube-Polymer Hybrid Material

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop multifunctional thermally and electrically conductive polymer-nanotube composites and adhesives.

DESCRIPTION: Polymer-nanotube composites offer the potential for great advantages over many of the materials used today for electrical and thermal management, on Air Force systems. These materials would result in as much as a 70 percent weight savings over metal-polymer composites, resulting in increased performance. Carbon nanotubes have previously been shown to possess high electrical and thermal conductivity by themselves. However, extremely limited work has been accomplished to determine the properties of truly uniformly dispersed tubes in a polymer matrix. The overriding difficulty in producing these systems occurs from an inability to disperse the carbon nanotubes completely uniform within a polymer matrix of interest.What is desired is a method to produce a uniformly dispersed carbon nanotube-polymer composite. The resulting technique should be applicable to a broad range of polymer systems. The composite should exhibit isotropic electrical conductivity greater than 25 S/cm and thermal conductivity greater than 50 W/m K. The finished product should be able to withstand traditional processing techniques such as extrusion or spray coatings with out loss of material properties.

PHASE I: Address the goals and requirements discussed above and demonstrate the viability of nanotube-polymer composites. Demonstrate feasibility of an electrically- and thermally-conductive polymer composite in accordance with the requirements listed in the descriptive section. Material samples will be fabricated and analyzed. Electrical, thermal and mechanical property data will be provided from testing the samples.

PHASE II: The product from Phase I would be further developed and optimized. Scale-up efforts will also be established.

PHASE III DUAL USE APPLICATIONS: During Phase III, the specific requirements of current Air Force platforms will be addressed. The Air Force has a variety of aircraft and satellite applications that a successfully developed material would find use in. Commercial applications include electromagnetic interference (EMI) shielding and enhanced thermal management for electronics packages.

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KEYWORDS:

AF02-134 TITLE: Virtual Nondestructive Evaluation (NDE): Computational Methods for Virtual Prototyping

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Virtual designing and nondestructive evaluation (NDE) prototyping - that is modeling and simulation of designs and processes, simulating NDE from conceptual design through the service life phase of component knowledge chain - will provide the means to predict damage tolerance and service life, as one of the design criteria..

DESCRIPTION: The project efforts of this topic would work toward the creation of a virtual environment at a computer terminal: perform design process simulations, project appropriate manufacturing processes; evaluation of the NDE models to determine the necessary inspections for quality control, and provide predictive assessments to evaluate service life and damage tolerance of both structures and response configurations of different designs. This topic will focus on the modeling and simulation aspects of the NDE responses as part of the design cycle of new materials and components, with the current NDE information/knowledge chain providing future predictions for material design, manufacturing, and service life cycle. This area will be a necessity for developing modeling strategy

for the Sensor Craft. A future system, currently in early design concepts, that would benefit from this type of effort would be the coherent conformal array technologies, focusing on the development of low profile, inexpensive conformal broadband active electronically scanned array (AESA) apertures. This system, and others still in design concept stage would represent particular application where virtual NDE can assist in design options for determining the optimum design for performance and manufacturing and life cycle processes. This conceptual modeling strategy is to include database construction for the purpose of predicting material property, understanding and visualizing the transition of micro to macro data and material development, predicting material performance, and capturing prototype life expectancies of components and manufacturing processes for the various design options.

PHASE I: Phase I is the development of conceptual design of the Virtual NDE process simulation. It is to map the direction of the modeling and prediction efforts. It should cover the approaches and the path of strategies of NDE knowledge utilization in virtual prototyping. The end product should be a feasibility strategy of inserting NDE models into a virtual design, manufacturing and maintenance environment. The strategy should also include some predictions on design components in the simulations of the component life cycle.

PHASE II: Phase II would further develop the model defined by Phase I. Visualization of NDE knowledge (that is: knowledge is obtained from experience and information and the information is extracted from the raw NDE data) are to be incorporated into the design cycle of defined examples of components. The value of designing for service life, the effectiveness of the models and simulations for the design, manufacturing, and service life options are to be analyzed and mapped with the cost/benefits of the computational approach performed.

PHASE III DUAL USE APPLICATIONS: Initial success, on a limited problem space, will spearhead the way for reliance on computational means to eliminate the expense of multiple first item design, manufacturing, and service life attempts. Here the final design will have examined many options, and determined the optimum approach, before any real (manufacturing) expense is incurred. In addition, the effects of aging will be incorporated into the design to find the optimum configuration for the entire service life of the part. This view has application to any business base that is creating (manufacturing) parts or components - aerospace, automotive, metals processing, and composite processing through a comprehensive view of predictive, virtual prototyping.

REFERENCES:

KEYWORDS: nondestructive evaluation (NDE), conformal antennas, modeling, simulation, design

AF02-138 TITLE: Distributive Processing Techniques For Interconnected Embedded Systems

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Investigate innovative distributive processing techniques for load sharing interconnected embedded processors.

DESCRIPTION: Operational Flight Programs (OFP) modifications continue to be the cost and risk drivers for munition and aircraft integration. Technology that would allow the automatic shifting of some processing tasks from the flight computer to the dispenser when necessary would result in an increase in system capability. As munitions decrease in size, the number of munitions that a bomber or fighter can carry increases. Current flight computers were not designed to handle the number of miniature munitions that a bomber or fighter can carry. Flight computers, especially in bombers, do not have the performance capability or the capacity to perform the required processing. Distributive computing technology maybe useful in distributing some of the flight computer processor load to the munitions dispenser. For example, tasks like power management, test diagnostics, target assignment, moment arm offset, and weapon status check, could be offloaded to dispenser's embedded processor. Current developmental smart dispensers are designed to be passive. They are smart only in the sense they carry smart weapons. With their limited processing capability, bombers and fighter aircraft cannot take advantage of their physical capacity to potentially carry several hundred munitions. Distributed processing techniques may help overcome this obstacle.

PHASE I: Investigate feasibility of using distributive processing techniques to increase the processing performance and capability of two or more embedded processing systems that are interfaced together. Innovative approaches are needed that would allow overburden processors to tap resources of other underutilized processors.

PHASE II: Develop and prototype a distributed processing architecture capable of automatically shifting the processing load between embedded processors. Develop an electronics/logical specification for the prototyped system.

PHASE III DUAL USE APPLICATIONS: Distributed computing has several useful military and commercial applications where embedded processors and or microprocessors base hardware are interconnected together – for example computer networks in a commercial or military command and control center, web servers, telephone switches, wireless weapons networks and local area networks (LANS).

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KEYWORDS: Operational Flight ProgramsDispenserMiniature MunitionsFlight ComputerDistributed ProcessingEmbedded ComputerReal-Time ProcessingLoad Balancing

AF02-141 TITLE: Micro Air Vehicles for Munition Bomb Damage Indication

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop technologies for integrating Micro Air Vehicles (MAV) with a munition to provide Bomb Damage Indication/Bomb Damage Assessment (BDI/BDA).

DESCRIPTION: Micro Air Vehicle sensors that can be attached and deployed from a munition can be an innovative concept for acquiring BDI/BDA information. Weapon impact location, inertial navigation system/global positioning system (INS/GPS) state at impact, fuze function, pre- and post- impact imagery are examples of information that could be gathered and relayed by a MAV. MAVs could have the ability to provide long duration imagery and/or sensing for BDA. Target characteristics and contents may be discernable for deeply buried targets. Additionally, counterproliferation concerns are driving requirements for target detection at low dosage levels. These munition deployed sensors could detect signatures of suspected agents. Miniature expendable air vehicles could be utilized for remote sensing and/or high-resolution imagery to fly through and/or track agent clouds without decontamination and reconditioning. To date only small investments have been made in fuze function recovery and munition deployed cameras. Further research is required for sensors, munition integration, assessments, and data links/data processing. The purpose of this topic is to investigate innovative concepts of a MAV for BDI/BDA, focusing on the design, deployment and stability of the MAV.One concept is to have the attacking munition deploy a MAV. The MAV will be attached to the munition upon launch from the host aircraft. At some point in the trajectory, this MAV will separate from the munition, stabilize, and fly to the target coordinates for post-impact BDA. The MAV needs to record the impact event and rebroadcast this data plus the BDA imagery back to an applicable platform. The packaging, separation, and stabilization of the MAV is technically challenging since the host munition may be traveling at near sonic velocities when the MAV is to separate. Technology investments that are necessary to utilize an MAV for BDI/BDA include the following: 1) Resolve issues involved with MAV separation/deployment – how is the MAV deployed from the munition so there is little or no effect on the host munition and allows the MAV to establish stable flight.2) Resolve issues involved with sensor selection (e.g., EO, IR, RF, etc.) – identify the most promising sensor for the widest range of munition operating conditions (e.g., day/night, weather, etc.).3) Resolve issues involved with data transmission (bit rate, power, antenna, range) and receiving platforms (UAV, satellite, etc.)

PHASE I: Identify and define the feasibility issues for an innovative overall MAV concept and design that is compatible with current weapons. Packaging, deployment, stabilization, and successful operation on the MAV are critical technology issues that need to be addressed in the feasibility effort. Low cost is an essential aspect for weapon implementation and should not exceed 20% of the munition cost.

PHASE II: Develop and perform a prototype demonstration. Conduct testing to prove feasibility over various operating conditions. Testing will consist of component test hardware fabrication, integration on a suitable test vehicle, and flight testing.

PHASE III DUAL USE APPLICATIONS: Remotely gathering information on fortification layout, criminal/ friendly disposition, etc. for use by law enforcement agencies in a terrorist or hostage situation.

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KEYWORDS: Sensors, video, surveillance, tracking, vision system, pattern analysis

AF02-142 TITLE: Bomb Impact Analysis and Damage Assessment via Remote Sensor

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Identify sensor technologies for gathering and assessing bomb damage indication/bomb damage assessment (BDI/BDA) from a munition deployed asset.

DESCRIPTION: Today's autonomous munitions are proving to be an effective means for prosecuting an air war. Standoff cruise missiles are used for opening days of the war and short time duration contingencies. Inertial Navigation System/Global Positioning System (INS/GPS) guided bombs have the potential to be the general purpose workhorse for future air campaigns. As a result of these autonomous munitions, direct overflight of the target is not required and aircraft loss rates have dropped dramatically. However, BDI/BDA is becoming more difficult with autonomously guided munitions. "Gun camera" imagery is not available from the delivery platform. High overhead imagery is either not available or is unable to discern target damage, especially for buried targets. The recent Kosovo operations demonstrated increased need for BDI/BDA associated with INS/GPS munitions. The percentage of unknown results for INS/GPS munitions was three times that for traditional laser guided bombs. The prospects for the future could be even worse with the advent of miniature munitions that will provide even less visible damage to the target. Without improved BDI, targets will be reattacked unnecessarily, requiring more sorties, munitions, etc.Munition attached and deployed sensors can provide valuable data for BDI/BDA without overflight by valuable manned aircraft or unmanned aerial vehicles (UAV). Weapon impact location, weapon function (i.e., did it detonate), pre- and post-impact imagery are examples of information that could be made available. We seek innovative sensor applications and/or development that will provide BDA/BDI from a "pop-off" vehicle. The sensor must be able to work in high and low light conditions and may also need to work in areas of low cloud cover. In addition, technologies need to be developed or exploited that will allow for autonomous processing of the gathered BDA/BDI data to provide a "level of confidence" in target destruction.

PHASE I: Design, develop, or exploit appropriate sensor technologies to gather information about a munitions performance. It is highly desirable to develop/design a sensor that can determine weapon performance for a deeply buried target. The sensor can either be part of the weapon itself or be deployed prior to impact. Phase I shall address methods for distributing data gathered by the sensor. Additionally, Phase I shall investigate processes that provide automated confirmation of target destruction from the sensor data.

PHASE II: Devlop, demonstrate, and validate a prototype sensor and processing algorithm. This will consist of test hardware fabrication, bench testing of components, and prototype sensor testing.

PHASE III DUAL USE APPLICATIONS: Dual Use Commercialization Potential: Application, integration, and test and evaluation (T&E) for remotely gathering information on fortification layout, criminal/friendly disposition, etc., for use by law enforcement agencies in a terrorist or hostage situation.

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KEYWORDS: sensors, video, surveillance, tacking, vision systems, pattern analysis

AF02-143 TITLE: Effects of Internal Weapons Bays on Advanced Munitions

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Investigate and quantify the effect of internal bay flow fields on smart weapon operation.

DESCRIPTION: Effects of internal bay flow fields on advanced munitions is somewhat unknown. These effects include: acoustics and flow anomalies due to air flow over an open weapons bay. Acoustic effects have the potential to destroy sensitive electronics (seekers, sensors, receivers, etc.) and reduce fatigue life of surrounding structures (fins, outer casings, ejector racks, etc.). Flow anomalies can cause unpredictable separations of miniature weapons, which could lead to catastrophic effects on weapons and in extreme cases aircraft.Steinburg [Ref. 9] describes the effects of acoustic noise on electronic equipment, and distinguishes between two types. The first effect is outright failure due to physical breakage (fatigue failure). The second effect is called microphonic. This is when a component is sensitive to acoustic levels due to the change in size (volume) of a device, which in turn changes the electrical properties of the device. Offerors should be equipped to analyze the effects of both types of acoustic drivers on sensitive weapons components, and to describe the costs of alleviating both types of effects. Active flow control has been investigated in recent years as a means to achieve higher levels of acoustic suppression. Offerors should also be prepared to roughly evaluate the cost benefit of powered devices which could deliver higher suppression levels vs the cost of passive damping or hardening techniques applied to the weapons themselves.

PHASE I: Characterization of the flowfield environment (acoustics, flow anomalies, etc.) within an advanced munitions internal bay over a wide range of Mach numbers and flight conditions. Define areas of concern and solutions for a variety of advanced munitions. Areas of concern include, but are not limited to, structural fatigue in munition and aircraft, electronics failure, and safe separation. Determine the cost, risk and extent of improvement over existing methods.

PHASE II: Build a prototype application of the equipment or software. Demonstrate under actual engineering conditions or demonstration under simulated flight conditions.

PHASE III DUAL USE APPLICATIONS: High-payoff military applications include massive delivery of small smart weapons to time critical targets anywhere in the world. Commercial applications include innovative techniques for delivering and recovering cargo to/from space, reducing acoustic noise in commercial aircraft landing gear bays, and cooling technologies for high-speed civil transport.

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KEYWORDS: Weapons Bay, Store Trajectory, Flow Control, and Acoustic Suppression, Weapons Separation, Cavity Acoustics

AF02-144 TITLE: Reconfigurable Computing Applications for Aircraft, Munitions and Dispensers

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Investigate and validate the feasibility of reconfigurable computing technology to increase processing capability, reduce parts obsolescence and integration cost.

DESCRIPTION: Current aircraft, dispensers and munitions interfaces requires costly hardware changes when upgrades are required. Innovative implementations of these interfaces are needed to reduce integration and upgrade costs. Recent advances in reconfigurable computing technology, offer opportunities to reduce cost and risk of munitions and aircraft integration. An additional benefit may also be gained in the area of parts obsolescence. Parts obsolescence in electronic components continues to be an issue in the military and commercial markets. Reconfigurable computing technology may solve this problem. The feasibility of implementing microprocessors and key electronic parts in gateware, to get significant increase in performance and capacity, needs to be investigated. Gateware is the merging of hardware and software. Gateware is not hardware specific, so if the hardware it resides on becomes obsolete, it is easily implemented on the new hardware. Since reconfigurable computing technology is reprogrammable, new or modified capabilities can be introduced to the war fighter in significantly less time and without having to re-certify electronics.

PHASE I: Perform creative analysis to determine effectiveness and technical feasibility of implementing reconfigurable computing technology (software upgradeable/reconfigurable hardware) to increase capability and compatibility and to minimize hardware obsolescence.

PHASE II: Develop and demonstrate an innovative prototype application using reconfigurable computing technology. Prototype hardware should be software reconfigurable and demonstrate a processing capability.

PHASE III DUAL USE APPLICATIONS: Reconfigurable computing technology has many commercial and military applications where hardware can be upgraded by software and real-time processing is required – for example Personal Computers, commercial/military avionics processors, weapon interface electronics and real-time image processing for x-ray equipment.

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3. Reconfigurable Computing: A Survey of Systems and Software: Authors Hatherine Compton, Dept. of Electrical and Computer Engineering, Northwestern University Evanston Ohio– Scott Hauck, Dept. of Electrical Engineering, University of Washington, Seattle, WA.

4. Role of FPGAs in Reprogrammable Systems: Author Scott Hauck, Dept. of Electrical Engineering, University of Washington, Seattle, WA.

5. Reconfigurable Computing At NASA Langley: http://transit.larc.nasa.gov/csb-www/reconfig.html

KEYWORDS: Parts obsolescence, Operational Flight Program, reconfigurable computing, Aircraft integration, Field Programmable Gate Arrays (FPGA), adaptive computing.

AF02-145 TITLE: Liquid Payload Expulsion and Aerosolization

TECHNOLOGY AREAS: Chemical/Biological Defense

OBJECTIVE: Develop and demonstrate a computational approach for simulating the ejection of liquid payloads.

DESCRIPTION: In some cases, weapons may be used to rapidly inject neutralization chemicals into masses of chemical or biological agents. Conceptually, this idea is valid, but there are currently no computational codes that can simulate the release and aerosolization of a liquid neutralizer. Although some empirical techniques exist, a high-resolution computational code is needed in order for detailed design and analysis work to be performed. The relevant physics is very complicated and is not adequately captured by simpler models. If a liquid neutralizer is to be used

against an aerosolized agent it follows that the neutralizer must be sprayed into droplets at the appropriate time in the detonation or expulsion event. If the droplets of neutralizer are too large, then the aerosolized agent may not be exposed to the neutralizer in a manner supporting neutralization. The same can be said for liquid agent stored in containers. Fragments may be used to open the containers, but it may be necessary to spray the neutralizer with a certain droplet size and within a certain time interval to promote neutralization. A high-resolution computational ability to predict droplet formation and aerosolization is needed to complement warhead experimental work in this area. Such a capability would also be important for couterproliferation analyses in addition to warhead design by being able to predict the release and aerosolization of agents from containers damaged by conventional munitions. Critical challenges in achieving this capability are the unsteady formation of droplets and the cascade from droplets to an aerosol. Specifically, an unsteady droplet formation/cascaded breakdown model would need to be developed based on the mechanics of turbulence and surface forces, and then cast in a framework consistent with subscale/LES (large eddy simulation) theory. Once integrated into a conventional LES turbulent flow CFD (computational fluid dynamics) code such a capability would prove extremely useful in warhead design efforts.

PHASE I: Develop an approach to deriving an unsteady liquid droplet formation and cascade breakdown model using the mechanics of turbulence and surface forces. Identify appropriate experimental data for validation efforts in phase II.

PHASE II: Develop an unsteady liquid droplet formation and cascade breakdown model and then formulate the model into a subscale/LES (large eddy simulation) framework. Test and demonstrate this model in a high-resolution Large Eddy Simulation (LES) CFD code. Validate the models and code against experimental data such as a turbulent jet or a turbulent free shear layer.

PHASE III DUAL USE APPLICATIONS: These new algorithms will be useful in commercial manufacturing applications, fuel injector design, and other industrial processes..

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2. Voke, Peter, et al., "Direct and Large-Eddy Simulation III (ERCOFTAC SERIES Volume 7)," Kluwer Academic Press, 1999.

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KEYWORDS: Large Eddy Simulation, Computational fluid Dynamics, aerosol, droplet formation, turbulence, unsteady

AF02-146 TITLE: The use of synthetic aperture radar (SAR) imagery for targeting of Laser Radar terminal seekers

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop an automated targeting concept to enable the use of synthetic aperture radar (SAR) data as a source of target information for active imaging seekers such as laser radar and SAR seekers.

DESCRIPTION: The Air Force is investigating technologies to support the next generation precision weapons and laser radar has emerged as one of the key technology candidates for application as a terminal seeker. Specifically, this task addresses the development of a technique to automatically extract required targeting information from both high quality SAR as well as aircraft quality SAR. The targets of interest are unplanned targets of opportunity, and include fixed (buildings, bunkers, etc), relocatable and moving targets. The effort must consider the weapon-borne 3-D seeker as well as the seeker algorithm used to support autonomous target acquisition and track.Background: Synthetic aperture radar imagery is one of the most prevalent sources of target imagery. SAR can produce high resolution imagery from aircraft standoff ranges and is the only source available in almost-all weather conditions. As such, it is important that precision weapons and specifically those with terminal seekers be able to take advantage of this data source for targeting purposes. Targets of opportunity are of particular interest and drive the need to rapidly develop requisite targeting information, typically from on-board a strike asset. The basic problem of interest here is a solution to the problem of transferring relevant information from one imaging active seeker (e.g., a SAR) to another imaging active seeker (a laser radar, or another SAR) with substantially different performance parameters, in real time, with minimal human intervention. Details: A great deal of work has been done in developing algorithms and mission planning concepts for laser radar for interdiction, suppression of enemy air defense, and other missions, both for fixed high value and ground mobile targets. Unfortunately, these algorithms and mission planning concepts rely on targeting information developed during ground based mission planning and the majority of the imagery products used are either

visible or infrared. The purpose of this effort is to attempt to use readily available SAR imagery for both ground based mission planning as well as real time, airborne mission planning.

PHASE I: Develop and evaluate candidate concepts to support transferring relevant image information from one active sensor (an air-borne SAR in the example) to another active sensor (a weapon-borne laser radar or SAR in the example). Phase I will result in a recommended concept with supporting analysis and rationale.

PHASE II: Develop detailed design for the recommended concept resulting from Phase I. Demonstrate the recommended concept through detailed modeling and simulation, using sensor parameters provided by the sponsor. Evaluate performance and provide resulting software and additional recommendations to the sponsor.

PHASE III DUAL USE APPLICATIONS: Automated transfer of imagery or equivalent information from one active sensor to another with different performance parameters could potentially be used to cue sensors to track objects, useful in tracking object's progress in processes and providing a means of process control.

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3. A. Jelalian, "Laser Radar Improvements", IEEE Spectrum, v18, n11, p46-51, November 1981, DTIC-ADD521219.

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5. Van Nevel, Alan; Peterson, Larry; Kenney, Charles , "Image Processing for LADAR Automatic Target Recognition," Report 1999, DTIC- ADA386513.

KEYWORDS: adverse weather sensor, autonomous target acquisition, smart weapon, cruise missile, signal/image processing, GPS altimeter.

AF02-147 TITLE: Improvement of Penetrator Performance by Increasing/Engineering Case Mechanical Properties

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop innovative concepts, processes and materials for improving strength and fracture toughness of steels.

DESCRIPTION: New and innovative concepts, processes and materials are required in the area of air delivered non-nuclear munitions that will have a dual use and high commercialization potential. Current methods for improving strength and fracture toughness are generally limited to reduction of sulfur content and adding substantial concentrations of cobalt and nickel. As a result, significant improvements have been made for the required properties but they have driven the cost of steel up 6-10 times that of ordinary steel. Now that it is known that the higher performance can be obtained, concepts and processes must be developed that will drive the cost down while maintaining the desired characteristics. The desired cost range is $2 to $4 per pound. Areas of research include improvements in quality control, functionally gradient materials, heat treatment, mechanical forming processes, micro-structural gradient control, reduction of inclusions that cause embrittlement and development of inclusions that improve strength in concert with fracture toughness. Exit target properties are as follows: a) 325ksi (235ksi minimum) Yield Strength and b) 34 ft-lbs (30 ft-lbs minimum) Charpy Impact Strength. The necessity for improvements is apparent as targets are further hardened, requirements for terra-dynamic steering are added and production costs continue escalating. Military uses include bombs, penetrators, sub-munitions, warheads, projectiles, fuze assemblies, aircraft structures, etc. Commercialization uses include higher performance and lighter weight car and truck frames, commercial aircraft structural components, bridge structures, etc.

PHASE I: Investigate new and innovative concepts, processes and materials for improving strength and fracture toughness of steels. Develop methodology of the proposed processes and establish control parameters. Demonstrate procedures are generally applicable and yield expected results.

PHASE II: Develop and demonstrate that the proposed concepts, processes and materials are valid and that the results are approaching properties established for materials such as HP9-4-20 up to AF-1410. Develop mechanical properties

data base for supporting hydrocode development and produce one-quarter scale prototype penetrators. These prototypes will be used to verify the strength and fracture toughness properties and demonstrate that the new composition developed is robust enough to justify further developmental testing.

PHASE III DUAL USE APPLICATIONS: This exploratory development program has extremely high utility for both the military as well as the commercial sector. Military tactical program objectives of increased penetration, terra-dynamic steering and reduced costs will benefit from the improved mechanical properties. Military aircraft developers will have greater latitude in design of weapon bays and deployment options by utilizing smaller, more efficient weapons. Commercial steel users such as aircraft manufactures, automotive producers and bridge contractors will have new materials available for new designs that are more efficient and cost effective.

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KEYWORDS: High Strength Low Alloy (HSLA) steel, nickel, chromium, cobalt, precipitation hardening, tensile yield strength, ultimate tensile strength, fracture toughness

AF02-149 TITLE: Agent Defeat Short Time Neutralization Data Collection and Modeling

TECHNOLOGY AREAS: Chemical/Biological Defense

OBJECTIVE: To determine short time (1-100 milliseconds [ms]) neutralization requirements of biological agents for counterforce weapon and model development.

DESCRIPTION: Knowledge of the neutralization rate of spores and other biological agents by heat, pressure and/or gaseous chemical neutralizers in the 1-100 ms time range is urgently needed to enable predictive modeling of weapon effectiveness and collateral damage resulting from attacks on targets containing biological agents. Current methods for determining the neutralization of biological agents (and simulants used in testing) by heat, pressure and/or gaseous chemicals are limited to times greater than 100 ms. In addition, the knowledge base in the 100 millisecond time frame is very limited and tends to be extrapolated down from the 1-5 second time frame where more extensive data has been taken. This requirement is for the development and application of methodology capable of determining neutralization for exposure times of 1-100 ms while being exposed to selected thermal, pressure and/or gas environments. It is anticipated that the methodology developed in this program will also be of use in the development of rapid sterilization techniques for biomedical and civilian biological agent defense/cleanup purposes.

PHASE I: Compile neutralization data from government and open literature sources. Develop a preliminary chemical reaction model and determine the types of input data required. Experimentally evaluate innovative techniques for the exposure of bioagent simulants to heat, pressure and selected gaseous chemical environments for defined periods of time in the 1-100 ms range. The design proposed must be capable of simulating the heat, pressure and chemical exposure provided by an actual weapon.

PHASE II: Construct and demonstrate the exposure testing system which looks most promising from the designs evaluated in Phase I. Determine the time dependence of neutralization of selected bioagent simulants under varying thermal, pressure and/or chemical environments over the time range of 1-100 ms. Modify the design as required to optimally simulate all of the significant environmental conditions occurring in an actual weapon employment. Refine the PHASE I model to fit the data generated. Verify the predictive capability of the model with an independent set of experiments.

PHASE III DUAL USE APPLICATIONS: Optimal conditions for thermally enhanced chemical flash sterilization, which offers the potential for rapid removal of microbial contamination from the surfaces of medical instruments and similar items, could be rapidly evaluated using the techniques to be developed here. Methods for neutralizing terrorist released biological agents could also be evaluated using these techniques.

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KEYWORDS: Heat, inactivation, neutralization, spore, bioagent, flash, sterilization

AF02-150 TITLE: Low Cost Universal Flight Termination System

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Demonstrate an innovative solution for a Universal Flight Termination System (FTS) for use in conventional weapons flight testing.

DESCRIPTION: In order to test a munition on Eglin AFB land ranges, as well as many other test ranges throughout the country, a munition must be able to terminate flight at any point during a mission when safety becomes a concern. The Range Commanders Council has developed a common design and testing requirements standard, RCC 319-99, that details Flight Termination Systems for virtually all government test ranges. The development of these devices, however, remains individualized to each program. Since qualification and testing of the FTS can be a significant amount of a flight testing budget, testers are looking for a "cheaper" and easier way to include FTSs in their munitions. The technical challenge is to innovatively standardize separate FTS components (i.e., Safe & Arm, receiver, antenna, etc) without violating constraints of RCC 319-99. For example standardizing the Safe & Arm device means that all munitions could use a general device to ensure that certain safety and performance requirements are met before the main charge of the weapon can be detonated. The standardization of FTS components would increase affordability by reducing research and testing efforts required by RCC 319-99 for each individual program. Instead, each program could focus on the actual performance of their munition.

PHASE I: Investigate innovative FTS solutions that are applicable to the greatest number of munitions. Select preferred method for phase II developmen

PHASE II: Design and construct solution selected in Phase I. Perform ground testing on various munitions to demonstrate the capability. Conduct validation testing of the concept for risk reduction and transition maturity to future flight termination systems.

PHASE III DUAL USE APPLICATIONS: There are several uses for the technology that goes into developing an FTS device. Some include use in mining, blasting, and demolition. Police or demolition forces could use this technology as a safe, reliable method to destroy terrorist bombs. In addition, commercial space launches could benefit.

REFERENCES:
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2. Mil Std 1316

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KEYWORDS: Munition, Flight Termination System, Electronic Safe and Arm, Explosives, Fuzes, Miniaturization

AF02-151 TITLE: Use of Kalman Filter Residuals for Independent Fuze Safeing

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Analyze using weapon navigation filter's residuals for verification of safe weapon separation for fuze safeing.

DESCRIPTION: Current military aircraft-launched weapons use an FZU-48 air turbine as a signal that guarantees that the weapon is in the unique environment of flight after release from the aircraft. This power signal to the fuze allows the fuze to be "safe" in all other conditions (accidentally released on the ground, etc.). The Air Force is interested in using battery power in place of the air turbine to save space and lower the drag induced from the turbine to verify that the bomb is indeed in the unique environment of flight away from the aircraft.The GPS/INS guidance system in current Air Force weapons has two independent sources of information that may suffice. The fact that the GPS receiver has locked onto multiple satellites demonstrates that the bomb is not shadowed or masked by the wing of the aircraft, and the accelerometers in the INS should sense drag and lift accelerations associated with flight. These signals are measured and combined in the Kalman filter to determine current position and velocity. It is proposed that the residuals between the latest measurements from the GPS and/or INS and the filter's estimates could then be used to determine the condition of stable flight after release from the aircraft.

PHASE I: An analysis of a characteristic navigation filter of an aircraft-launched weapon should be performed in a digital computer simulation to determine the appropriate residuals to indicate state change associated with weapon release (i.e., from captive carriage to freefall). A decision-making process to safe or arm the fuze should be generated and integrated into the computer simulation. Various scenarios of weapon launches should include aircraft dynamics, GPS/INS signal measurement, GPS antenna shadowing, and air data simulation for characteristic weapon launch trajectories.

PHASE II: A current weapon system's navigation filter and fuze safeing mechanism should be integrated in hardware and software, tested rigorously in the laboratory to analyze the fuzing change from safe to arm states based on various measurement inputs (e.g., acceleration measured by accelerometers, GPS satellite signals locking, etc.), and flight-tested.

PHASE III DUAL USE APPLICATIONS: Filter residual monitoring could be useful in any remote monitoring implementation. Spacecraft operations, remote sensor operation, unmanned submersible operations could all use this technology for status verification.

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KEYWORDS: Fuze Safeing, Fuze Arming, Inertial Navigation, Kalman Filter, GPS/INS, Accelerometer, Covariance Analysis, Residual Monitoring

AF02-152 TITLE: Intraweapon Wireless Communication

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Determine feasibility/methodology of communications between two locations in a penetrating weapon without physical links.

DESCRIPTION: Communication between functional elements of weapon systems has been historically accomplished by physical wires carrying electrical signals. However, for hard target penetrating munitions this communication link cannot be expected to survive during and after target penetration. Advanced counter-proliferation weapons concepts require multiple functions at different locations within the warhead to maximize effectiveness. The Multiple Event Hard Target Fuze, now in advanced development, is being tailored to accomplish these functions. However, due to technology limitations, each functional location must operate autonomously after impact. Therefore, we are soliciting an R&D effort to investigate a communication technology that can survive impact and still transmit at least a fire or detonation signal between locations internal to the warhead without time of phase shift during high impact penetration events. It is highly desirable that no warhead case modification be required.

PHASE I: Phase I of this effort will include design and analysis of the proposed communication concept(s). This analysis must include frequency modeling to determine compatibility and transitivity through various media in a munition. In addition, this analysis needs to address critical component survivability during munition impact Methods of verifying feasibility in Phase II shall be proposed and documented in a Phase II test plan.

PHASE II: Phase II will involve the detailed design, fabrication of and demonstration of prototypes. The government will provide tests at no cost to the contractor in a 3.6 inch diameter by 24 inch length projectile at velocities up to 1500 ft/sec with contractor supplied hardware including instrumentation, to provide a shock survivability analysis. The contractor should demonstrate the validity of the design with a demonstration of the communication between various locations in a muntion.

PHASE III DUAL USE APPLICATIONS: The developed communication link may have industrial application in transmitting data in harsh environments including directly through stationary or moving bulk media. Certain concepts, i.e., communication through ferrous media, could have direct application to vehicles such as transmission of auto or aircraft crash information. In addition, wiredata transmission through various media is a commercial enterprise in itself and includes many technology areas.

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KEYWORDS: Penetrators, explosives, signal transmission, warhead, fuzes, microwaves

AF02-153 TITLE: Innovative Sensor Precision Guided Munition Accuracy

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a method providing use of innovative sensors for precision guided munition accuracy enabling a 3 meter capability.

DESCRIPTION: Autonomous guided weapons concepts such as the Joint Air-to-Surface Standoff Missile (JASSM) currently use an infrared (IR) sensor and an automatic target correlation algorithm to remove errors induced in the coupled INS/GPS navigation system. Several IR pictures are taken prior to impact and used to update navigation errors induced either by GPS jamming or INS drift. Resultant guidance errors are reduced to less than 3 meters given greater than zero-zero weather conditions. However, this accuracy comes as a result of increased cost for the sensor and increased radar cross section due to the sensor aperture on the outer mold line on the front of the vehicle. Consequently, it is desired that a method be developed to provide 3 meter guidance. No gross impact in the mission planning aspects of the weapon system should be caused by the implementation of this guidance capability.

PHASE I: In Phase I of this effort, an innovative conceptual study on atypical sensor technologies, which will provide JASSM-like systems with a capability to precisely guide to ground fixed and mobile high value targets in day/night, adverse weather, and hostile environments without the use of a standard forward-looking sensor shall be investigated. Innovative sensors could include such technologies as magneto-resistive sensors, star trackers, passive optic flow sensors, etc. The candidate sensor shall be low cost and suitable to be integrated into the weapon airframe without major modifications. To test and evaluate the proposed sensor concepts, a preliminary simulation using JASSM parameters and requirements shall be conducted. A technical report, providing a detailed description of conceptual design of the candidate sensor processing approach and investigation result of the Phase I effort, shall be delivered to the sponsor. The conceptual study effort will be 9 months in duration.

PHASE II: In the Phase II effort, a prototype of candidate sensor will be developed, tested, and demonstrated based on the results of the Phase I conceptual study and design. The software/hardware development should be optimized for speed and performance and suitable for real time fight test demonstration. The researchers will have an option to conduct a captive flight test on slow speed platform (such as a helicopter) or a tower test based on technology offered. The researcher shall document the test and its result along with the software documentation, and deliver a final report to the sponsor at the end of Phase II effort. The development and demonstration of the system will be 24 months in duration.

PHASE III DUAL USE APPLICATIONS: The concepts developed and demonstrated during Phase II will be implemented, integrated, and demonstrated on a high-speed platform for JASSM applications. This technology also has potential for dual use applications in the following technology areas: Navigation, Surveillance, and Automatic Landing Guidance systems.

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KEYWORDS: guidance, navigation, control, precision navigation, magnetometers, optic flow, star tracking

AF02-155 TITLE: Automatic 3-Dimensional Wire-Frame Model Generation Algorithm

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop an algorithm to automatically build wire-frame models of targets from stereoscopic imagery.

DESCRIPTION: Automatic target correlation (ATC) algorithms for fixed ground targets often operate on significant edge features found in a scene, such as roof lines or corners of a building. The algorithms use these edge features to correlate with a target model that is generated in the "mission planning" phase of the effort. Because the algorithms operate on significant edge features, wire-frame models of the target's 3-dimensional structure are well suited for use in ATC algorithms. Unfortunately, the generation of the wire-frame models is a manual, labor-intensive, and time-consuming process that is prone to significant variation based on the skill and experience of the person generating the model. To alleviate these problems, it is desired that a computer algorithm be developed which will operate on stereoscopic imagery to automatically generate wire-frame models of a target and its scene. Systems such as the Joint Air-to-Surface Standoff Missile (JASSM), which currently requires the manual generation of models from stereoscopic imagery, will benefit greatly from such an algorithm.

PHASE I: In Phase I of this effort, a conceptual study will be conducted, which should address the issues involved in the generation of 3-D wire-frame models from stereoscopic imagery. The study should determine how to generate the

models such that they accurately represent the significant structures of a scene while disregarding the insignificant ones. A design of a system that can meet these goals should be proposed.

PHASE II: In Phase II of this effort, an innovative prototype software system will be developed capable of generating 3-D wire-frame target models from stereoscopic imagery. The system should have a moderate run time and be able to generate a 3-D wire-frame model that accurately represents the significant structures of a scene. At the end of this phase, a prototype should be demonstrated which accomplishes this task. During this phase, the prototype developed should be integrated into the JASSM mission planning platform, and further developed such that the models generated by the prototype are compatible with the format of the JASSM models.

PHASE III DUAL USE APPLICATIONS: This system in its final form is applicable to many areas of non-military interest. These include but are not limited to: robotics, CAD generation, 3-D cartography, and law enforcement.

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5. AFRL/MN Home Page: http://www.mn.afrl.af.mil

KEYWORDS: wireframe generation, stereoscopic imagery, image processing, feature extraction, Hough Transform, automatic target recognition, target model, automatic model generation, models, edge detection, scene analysis.

AF02-157 TITLE: Zero-Zero Target Sensor

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop algorithms and software to enhance air-to- ground accuracy in adverse weather and hostile environment.

DESCRIPTION: Systems using infrared (IR) sensors to perform automatic target recognition to remove errors induced in the coupled INS/GPS navigation system suffer reduced performance during zero visibility conditions (low level fog, rain conditions, etc.). To enhance the all-weather aspects of smart weapon systems a low-cost, adjunct sensor system is needed to allow all weather (zero ceiling – zero visibility) capability for targets requiring precision-guided munitions. Such an adjunct sensor would have to be low cost to not adversely affect the current air-to-ground smart weapon unit production price.

PHASE I: In Phase I of this effort, an innovative conceptual study of sensor algorithms to provide air-to-ground smart weapons with a capability to precisely guide the current INS/GPS navigation system to ground fixed and mobile high value targets in day/night, adverse weather, and hostile environments shall be investigated. The candidate sensor shall be low cost and suitable for integration into comparatively low cost munitions. The candidate sensor is not constrained to operate only in the infrared region of the electromagnetic spectrum. For example, the sensor could be radar, synthetic aperture radar or passive millimeter wave. A technical report, providing a detailed description of the candidate sensor/ processing approach shall be delivered to the sponsor. The conceptual study effort will be 9 months in duration.

PHASE II: In the Phase II effort, innovative candidate algorithms and software will be developed, tested, and demonstrated based on the results of the Phase I conceptual study. The software development should be optimized for speed and performance and suitable for a real time demonstration. The offeror shall document the test and its result along with the software documentation, and deliver a final report to the sponsor at the end of Phase II effort. The development and demonstration of the software will be 24 months in duration.

PHASE III DUAL USE APPLICATIONS: The concepts developed and demonstrated during Phase II will be implemented, integrated, and demonstrated on a high-speed platform for air-to-ground smart weapon applications. This

technology also has a great potential for dual use applications in the following technology areas: Navigation, Terrain Mapping, and Automatic Landing Guidance systems for commercial airline and NASA.

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3. AFRL/MN Home Page: http://www.mn.afrl.af.mil Keywords: adverse weather sensor, autonomous target acquisition, smart weapon, cruise missile, signal/image processing, GPS altimeter.

KEYWORDS: adverse weather sensor, autonomous target acquisition, smart weapon, cruise missile, signal/image processing, GPS altimeter.

AF02-159 TITLE: Munition Thermal Management

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Identify innovative methods and materials for the management of the internal thermal environment of small diameter munitions.

DESCRIPTION: The thermal management used in today's missiles, primarily insulation materials and component separation, may no longer be adequate for future munitions. Current reduction in munition diameter size has decreased the amount of space available for separation of heat generating components. This combined with the increased use of electronic components operating at higher temperatures has raised the internal temperature, especially for small diameter munitions. Additionally, as munitions are carried and operated at increasing speeds, the external heat transferred into the munition has increased. Innovative concepts and methods for internal thermal control are sought. Both active and passive processes are encouraged as potential approaches for this management.

PHASE I: Develop design concepts for internal weapon thermal management. Design concepts that can be used for small diameter munitions operating at high speeds.

PHASE II: Based upon the findings of Phase I, develop, test and demonstrate a thermal management concept. Demonstrate the capability of the concept to be packaged within a small diameter munition. The Phase II deliverables will include a working prototype of the developed concept.

PHASE III DUAL USE APPLICATIONS: Thermal management techniques that are useful for munitions should be beneficial to various commercial applications. The automotive, computer and aviation industry all have high temperature operating environments. With modifications to the packaging, thermal management concepts developed for munitions may be able to be employed to alleviate undesirable operating temperatures found in many commercial applications.

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2. Ponnappan, Rengasamy, “Thermal Management Research Studies. Volume 1. Electronics Cooling,” UES-225-TR-96-1-VOL-1 (ADA326973).

3. Bootle, John, “High Thermal Conductivity Composite Structures,” TR-1000-0282 (ADA371758).

4. AFRL/MN Home Page: http://www.mn.afrl.af.mil

KEYWORDS: Thermal Control, Insulation, Heat Exchangers,Cooling, Heat Sinks, High Velocity Friction, Thermal Management

AF02-160 TITLE: Low Cost Manufacturing of Range Extension Wing Kits

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Investigate and evaluate innovative materials/manufacturing processes for a low cost range extension wing kit.

DESCRIPTION: Recent flight tests of winged autonomous munitions have demonstrated the ability to significantly increase the range of non-powered weapons. Additionally, with smart electronics, range extension kits improve munition maneuverability and improve the impact accuracy of current munitions. Both aspects are desired by today's Air Force. The need to reduce the amount of time our pilots are within enemy defensive systems is met by increasing the standoff range of our munitions. The desire to improve target accuracy, enhance munition effectiveness and reduce collateral damage is also met. What still needs to be addressed is the wing kit cost effectiveness in meeting these goals. Current range extension wing kit designs utilizing standard manufacturing processes and materials are costly and require an extensive amount of time to procure. Research exploring innovative manufacturing techniques along with wing kit material selection is required. A solution is the design of a new wing kit with manufacturing cost as a primary driver. Having proven the value of range extension wing kits, it is now necessary to explore how wing kits can be produced at low cost (<$3,000). It can be assumed that the number of kits for procurement is approximately 12,000. Any new design must meet or exceed current performance capability specifically packaging constraints and munition effectiveness.

PHASE I: Design a new range extension wing kit supported by innovative material selection and manufacturing/joining processes to reduce cost; and/or evaluate current wing kit designs using cost effective manufacturing techniques and materials. Select preferred method for phase II development.

PHASE II: Demonstrate the capability to manufacture a more cost effective wing kit and meet current performance requirements as determined in phase I. Perform ground structural tests, deployment tests and aerodynamic tests under realistic operating conditions, to evaluate performance.

PHASE III DUAL USE APPLICATIONS: Utilization of a cost effective combination of manufacturing process and material selection can benefit the commercial sector in a variety of products. Specifically, low cost processes and materials for joined and moving parts can benefit. These products can range from spoilers on sport vehicles to external winglets on commercial aircraft. Military applications can extend to a broad spectrum of precision guided munitions.

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4. AFRL/MN Home Page: http://www.mn.afrl.af.mil

KEYWORDS: Low Cost Manufacturing, Innovative Manufacturing Techniques, Cost Reduction, Hybrid material Structures, Range Extension Kit, Winged Autonomous Munitions

AF02-163 TITLE: Development of Structural Explosives for Low Collateral Damage (LCD) Warheads

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Demonstrate a structural explosive material for a LCD case having penetration survivability and non-hazardous fragments.

DESCRIPTION: Considerable progress has been made over the last forty years in precision strike. It is possible to hit targets with pinpoint accuracy and destroy targeted structures – but there is still a high potential for unwanted injury and damage near the target area caused by blast and case fragments. It is highly desirable and even necessary in many situations to avoid the collateral damage typically associated with today's weapon options. To support new weapon concepts for urban warfare, a new development program has been initiated with the aim being to substantially reduce bomb blast lethal radius while actually increasing near-field blast effects. To compliment this, a second technology is needed which would provide structural materials for warheads that are rapidly consumed in an explosion – thus eliminating the case fragments that create a large lethal radius in today's weapons. One concept is to build weapons

with structural explosives. Reduced blast radii from structural explosives, combined with precision strike, will provide war-planners access to weapons with a limited collateral damage footprint. This investigation will develop structural explosive materials and warhead designs that can meet "low collateral damage (LCD)" bomb requirements. It is conceivable, for example, that metal powders could be pressed into solid metal parts which, when sufficiently shocked, would disintegrate and burn or detonate. Goals for this effort are to formulate and demonstrate materials for this application. In a phase II effort, develop warhead concepts that would provide the required strength for weapon carriage and penetration survival into relatively soft targets.

PHASE I: Investigate new and innovative structural explosive materials. Develop formulations and fabrication methodology for the proposed composite materials and processes. Identify concepts for producing prototype fuze wells and warhead cases.

PHASE II: Demonstrate that parts can be scaled up and still yield anticipated results. Demonstrate that the structural explosive concepts and processes are valid and reproducible. Develop a mechanical properties database for development and production of full-scale warhead components. Produce and demonstrate full-scale warheads or warhead subsections.

PHASE III DUAL USE APPLICATIONS: This exploratory development program has utility for both the military and commercial sector. Military tactical planners will have greater latitude for precision strikes in urban areas that will result in reduced civilian death and destruction. Commercially, this technology may be applied to nano-scale intermetallic composites for improved properties of mechanical strength and flexibility, commercial pyrotechnic materials for material cutting, and new ceramics for ballotechnic and pyrotechnic composites.

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KEYWORDS: Structural Explosive, Low Collateral Damage, Dense Metal Explosive, Non-Fragmenting Case, Reduced Lethal Radius, Intermetallic Composites

AF02-166 TITLE: Munitions Research

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop innovative concepts in areas associated with air-deliverable munitions and armaments.

DESCRIPTION: The Air Force Research Laboratory Munitions Directorate's mission is to develop, integrate, and transition science and technology for air-launched munitions for defeating ground-fixed, mobile/re-locatable, air and space targets to assure the preeminence of US air and space forces.a. The Assessment and Demonstrations Division is seeking new and innovative ideas for future weapon integrating concepts, such as urban combat weapon, close air support weapon, low cost miniature cruise missile, counterproliferation weapon, time-critical target defeat, functional defeat of hard targets, and limited collateral damage weapons. Technologies under consideration include weapon design, innovative flight controls and range extension technologies, compressed carriage and ejecton technologies, micro technologies, processor, and transmitter technologies, and integrated subsystem techniques. Modeling and simulation tools of interest include high-fidelity physics-based codes for warhead design and penetration analysis, engineering-level tools for weapon/target interaction analysis, and system-level analysis for theater-level modeling. New concept and innovative tools are sought for system-level evaluations, the prediction of functional relationship of fire and/or blast effects on fixed structures, and dispersion of chemical/biological neutralization agents in a high-temperature environmentb. The Advanced Guidance Division seeks new concepts in areas associated with closed-loop guidance of autonomous munitions including inertial sensors, antijam (AJ) Global Positioning System (GPS), and terminal seekers, including electro-optical, millimeter-wave, and synthetic aperture radar seeker technology, and the components thereof, and the signal/image/data processing used in such areas. Concepts of interest include (1) guidance software, including guidance laws, estimators, autopilots, and AJGPS software, (2) innovative signal and image processing, and (3) operations/functions involving noise elimination, detection, segmentation, feature extraction, classification, and identification. Fundamentally new approaches to closed-loop autonomous guidance based on biomimetic principles are of particular interest. c. The Ordnance Division is seeking new and innovative ideas/concepts to support the development of advanced warheads, and explosives for use in air-delivered conventional munitions to defeat ground, mobile, air targets, as well as above-ground and buried structures. Technologies developed should

ultimately result in new and innovative components which are needed to meet the complex future munitions requirements for general-purpose bombs, penetrating warheads, safe-arm-fire devices, explosive detonators, explosives and advanced energetic materials, and devices for collecting data to be used in warhead design and analysis. Technologies for defeating weapons of mass destruction, including biological and chemical agents, and/or access denial to stored weapons, are of interest.

PHASE I: Determine the technological or scientific merit and the feasibility of the innovative concept.

PHASE II: Produce a well-defined prototype product or process.

PHASE III DUAL USE APPLICATIONS: a. Commercial dual-use applications for innovative flight vehicle technologies could improve air vehicle performance, as would air foil products, i.e., wind turbines, turbomachinery, etc. Simulations of effects would reduce test costs and provide greater capability for safety officials and insurance underwriters to assess associated hazards. Improved simulation models could benefit commercial building demolition, safety-related assessments, auto safety research, explosives research, mining, drilling, and a wide range of product analysis and evaluation activities.b. Commercial dual use applications for these guidance technologies include sensors, processors algorithms applicable to medical imaging, commercial aviation (adverse weather penetration), remote sensing and surveillance. c. Commercial dual use application for these ordnance technologies include facility/plant security and monitoring, high speed wireless data transmission, micro-electrical mechanical devices for controls and collision avoidance, high powered energy storage devices (capacitors and batteries) and environmentally responsible recycling of energetics and other materials.

REFERENCES:
1. AFRL/MN Home Page: http://www.mn.afrl.af.mil

KEYWORDS: (a) demonstration, assessment, airframe, munition, simulation, weapon (b) terminal guidance, autonomous guidance, automatic target recognition, precision guided munitions, sensor technology, seeker technology, autonomous target acquisition, signal and image processing, pattern recognition/classification, image understanding, artificial neural networks, fuzzy logic, superresolution, knowledge- and model-based vision, data fusion, biomimetics (c) target detection; hard target defeat; warheads; explosives; fuzes; safe, arm, fire devices; nanoparticles; simulation; chemical neutralization.

AF02-167 TITLE: Miniature Initiation System Technology (MIST)

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: To develop the key technologies to allow precise selectable initiation points within advanced miniature warheads.

DESCRIPTION: Recent advances in warheads that employ multiple Exploding Foil Initiators (EFI), coupled with EFI advances, offer the promise of very advanced kill mechanisms. In order to achieve the anticipated gains within ever shrinking warhead size, significant advances must be accomplished in the total EFI firing systems. Firing component (i.e., EFI, solid state firing switches, high energy density capacitors) improvements must be integrated into a system that will allow maximum flexibility of firing, both in selection and sequencing of initiation points, while minimizing size, especially within the active warhead functional area. The total system must eventually encompass safing and arming functions, voltage multiplication, high voltage storage, and switching as well as all necessary communication links. Significant trade off must be accomplished to assure maximization of firing flexibility and small size while maintaining adequate safety and reliability.

PHASE I: Investigate the feasibility of the proposed Miniature Initiation System Technology (MIST) concept. This investigation should include functional allocation, safety methodology utilized between modules and identification of high-risk components/modules. As a minimum, the function to be accomplished at each firing point shall be demonstrated at the breadboard level. These functions must be capable of being packaged in less than .1 cu. in. in the Phase II effort. It is highly desirable to minimize this volume.

PHASE II: The Firing Point Module (FPM) shall be packaged in its final volume of less than .1 cu. in. and demonstrate its capability to initiate PBXN-110. The complete MIST shall be breadboarded to the extent necessary to sequentially initiate four FPMs in a dynamic environment (PBXN-110) initiation phase.

PHASE III DUAL USE APPLICATIONS: Low voltage blasting cap technology (for mining and oil field use) has progressed to the point that electronic delays are now included within the blasting cap (detonator). In contrast,

increasing commercial blasters are switching to Exploding Bridgewires (EBW) and EFIs because of their inherently greater safety. The successful completion of this SBIR effort could combine the flexibility of advanced blasting caps with the increased safety and EFIs.

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KEYWORDS: slapper detonators, high voltage switches, high voltage capacitors, miniaturization, exploding foil initiators, capacitive discharge unit,

AF02-168 TITLE: Enhanced Laser RADAR Through Augmenting Signal Information Content

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Augment 3-D ladar seeker concepts via optical multispectral/polarization/passive imaging information while minimizing additional hardware.

DESCRIPTION: The current approach to advanced laser radar seeker systems for munitions is to measure target shape and match that to a template of known targets. While this target signature is invariant with time of day, temperature and other environmental variables, the signature can be defeated by suitable modification of the object.The purpose of this topic is to maximize the information collected by the seeker using a single optical CCD sensor. Specifically, it is envisioned that additional target information could be collected within the spectral sensitivity of the sensor simultaneously with the shape information derived from laser radar. The advantage is that combinations of signatures, such as augmenting the shape signature with a spectral signature, provide more information content and therefore are significantly more difficult to defeat than a shape signature alone. The additional information could include spectral information, passive inband imagery, and the polarization state of the laser radar return.Temporally simultaneous approaches are preferred, but temporally multiplexed approaches are acceptable if the time to acquire all the necessary data is insignificant in terms of munition and battlefield dynamic time scales. Flash laser radar concepts are preferred, i.e., those where the entire field of view is imaged with a single laser pulse. Truly novel scanned laser radar approaches that are enhanced to provide multiple active or passive wavebands are sought as well.

PHASE I: During Phase I, the recipient would propose a complete design for a fused multispectral and/or polarimetric ladar system.

PHASE II: Phase II of this project would involve the construction and delivery of a prototype system based upon the design investigated in Phase I.

PHASE III DUAL USE APPLICATIONS: A wide range of commercial and military applications exist for the technology addressed in this topic, including medical applications, weather forecasting, communications, manufacturing, and remote sensing. Commercial laser radar applications include geographic surveying, industrial monitoring, adaptive cruise control and collision avoidance, and automated aircraft landing and docking of space vehicles. Military laser radar applications include seekers for autonomous munitions guidance, surveillance and reconnaissance sensors and precision targeting systems. Additional optical information such as multispectral and polarimetric variants of laser radar can enhance the general performance of existing ladar systems.

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KEYWORDS: Laser radar, seeker, munition, polarization, multispectral sensing, polarimetry, spectrapolarimeter, flash ladar, data fusion.

AF02-169 TITLE: Navigation Solutions by Terrain Imaging

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Examine use of imaging sensor output to aid inertial measurement unit.

DESCRIPTION: Guided munition (or flying robot) stability and navigation functions require ownstate information. Conventionally this is provided by an inertial measurement unit (IMU). The IMU-based solution drifts due to the quality of the IMU, as reflected in the IMU error budget. Currently Global Position System (GPS) receiver output is used to bound the IMU error; the GPS provides position information (good for navigation) but not body attitude information. Past efforts have shown that position information can be updated by identifying "nav points" on the terrain and matching them to an onboard terrain map, but this is not the capability we seek. Rather, we wish to develop the capability to cleverly process information from an imaging sensor output to aid the inertial measurement unit for both the stability function and the navigation function. There are techniques within the field of optic flow which seem promising in this arena but any feasible concepts will be considered.

PHASE I: Analysis showing sensitivity of seeker-aided-navigation to seeker parameters such as instantaneous field of view, field of view, frame rate, etc., for both active and passive seekers; specific equations to enable calculation of egomotion (estimation of ownstate vector in 6 degrees of freedom) for both active and passive imaging seekers; preliminary designs for proof of principle (POP) concepts for passive seeker and for an active seeker.

PHASE II: Refine analysis accomplished in phase I; revise proof of principle (POP) designs; POP demonstrations: off the shelf imaging sensor output blended with IMU output to demonstrate that seeker output can aid stability and navigation solutions, quality and limitations of such an approach.

PHASE III DUAL USE APPLICATIONS: Replace IMU, GPS receiver on munitions through clever use of imaging seeker output. This technology could also be used for autonomous precision landing systems for commercial aircraft.Related

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KEYWORDS: Navigation, Stability, Optic Flow, Visual Flow, Image Flow, Terrain Mapping

AF02-170 TITLE: Positron Energy Conversion Based Weapons

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Conduct a Proof of Principle Experiment to show the Feasibility of an aspect of Positron Energy Conversion Based Weapons

DESCRIPTION: Positrons brought into contact with electrons produce energy according to the E=MC^2 equation. This is the highest energy density of which we are currently aware. This tremendous energy source offers a near unlimited opportunity for the weapons designer of the future. Recent developments in the production, containment and lethal effects assessment of positrons show that it may be feasible to build warheads for air launched weapons that will use the energy from positron - electron annihilation to provide a "dial-a-yield" capability. The possible lethal modes include gamma photons, electromagnetic pulse (EMP), heated plasma, and blast/fragments. Suitable targets for bursts of gamma photons are biological weapons of mass destruction. Electromagnetic pulse warheads are especially effective against targets containing electric circuitry. Heated plasma will be effective for penetrating armored targets. The kinetic effects of blast fragment warheads are effective against soft fixed and mobile targets. These weapons will have the added advantage of leaving no nuclear residue. This is because the gamma rays produced upon annihilation are only 0.511 million electron volts and are too weak to cause nuclear reactions. Positron annihilation energy can also be converted into propulsive energy to power turbojets and ramjets. Development effort is needed to establish the knowledge base for maturing the required technology for these weapons over the next 25 years. The key technical challenges are in the areas of positron production, confinement, and conversion. Production techniques include linear accelerators, high power lasers, and sodium 22 methods. Confinement concepts include electromagnetic Penning traps, magnetic mirrors, and spheromak techniques. Small scale laboratory conversion experiments for warhead (lethal effects) applications include gamma ray burst, metal plasma, metal vapor/liquid and kinetic energy demonstrations. Small-scale conversion experiments for propulsion applications include heat deposition and convective heating demonstrations. Innovative and creative approaches to laboratory level experiments at the proof of principle levels of positrons (10^12 to 10^15 positrons) are envisioned for the efforts proposed under this topic. This level of experiments is within the funding constraints of the SBIR program. The AFRL/MN will coordinate positron production experiments with current positron production facilities such as Lawrence Livermore National Lab. Proposals are expected to address a specific approach to production or confinement or conversion.

PHASE I: Select a promising approach to production or containment or conversion of positrons and conduct a feasibility study on performing a proof of principle experiment of a specific aspect of positron production or confinement or conversion.

PHASE II: Perform a prototype demonstration based on Phase 1 Feasibility results. Design, fabricate test hardware, and conduct a laboratory level experiment for a positron production or containment or conversion demonstration.

PHASE III DUAL USE APPLICATIONS: Positron energy storage devices may have significant commercial application in the future as a heat energy source for electric power generation using thermocouples. These "batteries" could power all types of hand held appliances or tools. This phase of the effort would tailor positron energy conversion for application to these commercial uses.

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KEYWORDS: Antimatter, Annihilation, Positron Production, Positronium, Positron Confinement, Penning Traps, Magnetic Mirror

AF02-171 TITLE: Biomimetic Concepts for Situational Awareness

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Demonstrate applications of insect biology inspired concepts for sensors and processing in autonomous air vehicles.

DESCRIPTION: The purpose of this project is to develop and demonstrate guidance, navigation, and control (GNC) sensors and sensor processing that will enable an autonomous air vehicle to achieve situational awareness in order to search for, detect, acquire, and track a target in a densely cluttered environment. Air vehicles of this kind may operate individually or cooperatively and, as such, each vehicle must possess situational awareness to avoid collision with other entities in its vicinity (e.g., objects, other similar vehicles, other targets) as well as be capable of extracting sufficient detail about the target to discriminate it from other targets, countermeasures, or non-targets. There are both military and non-military (e.g., search and rescue) applications for this capability. The relevant technologies include wide field-of-regard (e.g., 2 pi steradian) seekers, navigation sensors, optical flow guidance concepts, sensor fusion, and hybrid analog/digital processing. Because of the anticipated computational requirements to implement these capabilities in real systems, sensor configurations and hybrid analog/digital processing concepts inspired by the neurobiology of flying insects is encouraged. Insects integrate information from inertial sensors (e.g., halteres in Diptera), air flow sensors (e.g., Johnston's organ on antennae), internal strain sensors (e.g., campaniform sensilla at the base of wings and halteres), and position sensors between adjacent body parts (prosternal organ) with information from the compound eyes (e.g., imaging, optic flow) and ocelli (light intensity) for precision navigation and flight through complex environments. With inspiration from relevant research in these areas, a GNC sensory system design is to be developed for a suitable air vehicle prototype. Desirable characteristics of the system include: 1. Situational awareness capability for obstacle avoidance (e.g., buildings or trees, power lines, overhanging branches, or other air vehicles) 2. Detection, acquisition, tracking, and guidance to moving targets in background clutter, 3. Tolerance to transient sensor information distortion or obscuration, 4. Low cost, complexity, design overhead of implementing the GNC sensor concept (e.g., analog processing versus complex digital imaging algorithms).Rapid advances in micro component (e.g., sensor, actuator, and processing) technologies will soon make it possible to produce small air vehicles that are physically capable of precision flight. The design of GNC sensor systems to exploit the potential capabilities of this hardware is critical to realizing autonomous/cooperative precision flight. Although the knowledge base of insect neurobiology is quite large, insect biomimetics, especially as applied to aerospace operations, is a relatively immature field. GNC sensory system designs based on flying insect biology have yet to be demonstrated. Thus, a significant goal of the project is to conduct a demonstration of a candidate GNC sensory system in a prototype sensor hardware-in-the-loop test. For this reason, availability of prototype sensor and processing hardware, as well as appropriate test facilities, must be considered. In preparation for the hardware test, a preliminary evaluation of the candidate components or subsystems in bench tests, using hardware of appropriate fidelity to demonstrate the feasibility of the concept, should be conducted.

PHASE I: From suitable insect neurobiology candidate concepts, demonstrate that a GNC sensory system for autonomous/ cooperative precision flight is feasible. Demonstrate a limited prototype GNC sensory system (e.g., sensor and processing components or subsytems with prototype algorithms) in bench tests. Develop a test plan for conducting a Phase II sensor hardware-in-the-loop demonstration.

PHASE II: Refine the prototype GNC sensory system design tested in Phase I for more extensive sensor hardware-in-the-loop testing. Further demonstrate the feasibility of this approach under simulated flight scenarios. Prepare and conduct a demonstration using prototype sensor hardware in a suitable hardware-in-the-loop facility.

PHASE III DUAL USE APPLICATIONS: Commercial and military applications would include small surveillance and reconnaissance aircraft as well as AF unmanned air vehicles (UAV), and tactical autonomous/cooperative munitions.

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KEYWORDS: neuromorphic processingbiomimetic sensorsbiomimetic guidanceinsect vision3 dimensional egomotion computationarthropod vision systems

AF02-175 TITLE: Aero Propulsion and Power Technology

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop innovative technologies which provide major improvements in gas turbine engines, advanced propulsion systems, electrical power systems, and advanced fuels for manned and unmanned applications.

DESCRIPTION: The Propulsion Directorate aggressively pursues and solicits innovative ideas offering major performance advances in all areas of airbreathing propulsion including turbine engines, advanced and combined cycle engines, fuels, and electrical power. Payoffs include increased aircraft and weapon system effectiveness, survivability, reliability and affordability. Turbine engine technology development is focused on delivering higher thrust-to-weight ratios, reduced cost, improved efficiency, and increased reliability. Advanced and combined cycle engine efforts are focused on developing innovative and high Mach airbreathing engines for future manned and unmanned applications. Fuel technologies are currently focused on improving the performance (thermal stability, low temperature properties, etc) of JP-8 through the use of additives. Finally, electrical power efforts (non-propulsive) are focused on advanced techniques for power generation, storage, and distribution for aircraft, spacecraft, and weapons with a particular emphasis on directed energy weapons. Subsets of these technologies include innovative combustion measurement techniques, diagnostics, control techniques, microelectromechanical machines (MEMS), and engine related materials technologies. Offerors are strongly encouraged to establish relationships with suppliers of the aerospace systems relevant to their research in order to facilitate technology transition. Proposed efforts shall emphasize dual-use technologies that clearly offer commercial as well as military applications. Proposals emphasizing "spin-on" technology transfer from the commercial sector to military applications are also encouraged. Proposals also submitted for any other Air Force FY02 Small Business Innovative Research (SBIR) topic shall not be considered for this topic.

PHASE I: Develop the concept and perform analyses and subscale testing to demonstrate the feasibility of the proposed technology. Modeling and simulation is encouraged to guide the research.

PHASE II: Provide detailed analytical derivations and prototypical device or hardware demonstrations. Develop a technology transition and/or insertion plan for future systems and commercial ventures.

PHASE III DUAL USE APPLICATIONS: New and innovative propulsion and power technology is equally applicable to both military and commercial aircraft engines and power generation and distribution systems.

REFERENCES:
Air Force Research Laboratory Propulsion Directorate website address: http://www.pr.wpafb.af.mil

KEYWORDS: Turbine engines, high speed propulsion, scramjets, fuels, lubrication, power systems

AF02-176 TITLE: Improved Composite Duct Design for Increased Safety Margin or Weight Reduction

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Improve the accuracy of analysis predictions and testing methodology for buckling of polymeric matrix composite turbine engine ducts with large structural anomalies such as cutouts, reinforcements around cutouts, or flanges.

DESCRIPTION: Composite ducts are currently being used on various military gas turbine engines, specifically for the benefits of weight and cost reduction. However, certain studies have shown that the maximum weight reduction potential may not be realized due to current design practices and methodologies. Although an extensive amount of research has been conducted in the area of composite shell/cylinder buckling, the methods that provide accurate solutions are very difficult and costly to use, and therefore tend not to be used in typical day-to-day design practice. Simpler, approximate methods are used, however they fail to predict the actual buckling failure load, location, and buckling mode of the duct in a repeatable manner. Another concern is that, although composite ducts have proven

capable of meeting the structural requirements of the engine and are flying in the field, it is not really known how good the ducts are in terms of safety margin. The current track record for composite ducts is good in terms of repairs and failures, which may indicate that the ducts are over designed. This is not a problem until performance and cost demands are stringent, and the reinforcements around cutouts and flanges are reinforced to the point of taking away any weight or cost benefit that could be realized if the duct was not over designed. Unique and innovative approaches are sought for improving current design methodologies used for designing large composite ducts with large cutouts and various flange configurations. Approaches are sought that could be incorporated into any company's design practice and analysis codes, but an independent software code is not sought.

PHASE I: Phase I should concentrate on the analysis portion of the objective, with fabrication and testing left for Phase II. Identify an approach that will provide a more accurate prediction methodology for buckling of composite ducts with large cutouts. Validate the feasibility of the approach, and identify a plan for applying to subscale and full-scale com-posite ducts.

PHASE II: The prediction methodology identified in Phase I shall be validated by fabricating and testing composite ducts with large cutouts. Improved, more accurate methods of performing buckling tests of large composite ducts shall be identified and applied during the testing portion of the program. The test results shall be correlated to the test predictions, and the methodologies shall be updated as appropriate.

PHASE III DUAL USE APPLICATIONS: This technology will benefit both the military and commercial engine businesses. The buckling methods used in this program can be used to design improved ducts for the land based turbine arena as well, although the use of composites through advanced manufacturing methods would provide a better impact on the cost side than the weight side for land based turbines. The information achieved in this program is also applicable to airframe structures, since composites are being used for large, curved panels with large cutouts as well.

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KEYWORDS: Turbine Engine Ducts, Polymeric Matrix Composites, Buckling, Cutouts, Buckling Analysis, Buckling Testing

AF02-177 TITLE: Innovative Onboard Power and Cooling Solutions

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop an onboard capability that will generate 1000 KVA (1 Megawatt) electrical output and increase cooling capacity and thermal management for transport aircraft.

DESCRIPTION: The primary product is an on-board alternative power and cooling capability to be installed in a pressurized or unpressurized location of heavy aircraft requiring supplemental electrical power and cooling capacity for special applications including countermeasures and directed energy weapons. This capability would also permit aircraft systems to be operated without ground support equipment or generators driven by the main engines. Innovative research is desired to provide solutions for the supply of 1000 KVA continuous electrical output (110 V, 400 Hz, 3 phase ac) and operation with JP-8 fuel at altitudes up to 40,000 ft. The system should also simultaneously supply large quantities of pressurized air (approximately 800 lbm/min at approximately 50 psia) to drive an environmental control system or offer alternative high capacity cooling approaches. The very ambitious goal is to provide this added

capability at a weight of less than 1400 lbs. Conventional auxiliary power units that offer this combination of power and compressed air are not available and scaled versions would exceed the weight goal. Solutions using several smaller conventional units are also too large and heavy. Unique turbomachinery architectures are one possible approach, though other less conventional or emerging technologies (e.g., solid oxide fuel cells coupled with electrically driven compressors) may satisfy the requirements. Should the research show that a solution using multiple units (e.g., 4 units of 250 KVA continuous rating) is preferred, this is acceptable. Solutions must be achievable in 5-7 years and consider realistic design constraints imposed by reliability, operational and maintenance safety, and ease of maintenance, installation, and removal. Volume should also be minimized. Potential offerors are strongly encouraged to establish relationships with larger contractors who may be more capable of transitioning any technology developments.

PHASE I: Efforts should focus on performing research on technology and systems options, establishing measures of merit for selecting that concept offering the best value, and selecting this best value concept. Hardware, software, and integration requirements of each potential solution should be considered.

PHASE II: Provide systems model and simulation of proposed system. Simulate the performance of the best value concept. Conduct in-depth analysis to verify overall system benefits. Design, develop, and demonstrate key elements of the selected power and cooling system; testing should be sufficient to completely validate performance.

PHASE III DUAL USE APPLICATIONS: The anticipated military application of these technologies is future insertion into heavy aircraft with large power and cooling demands. The commercial market includes standby and mobile electrical power generation sources that could also supply cooling capacity.

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3. Smith, Glenn et al., "Integrated Power Unit - Advanced Development," SAE Paper 981281, April 1998.

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KEYWORDS: auxiliary power unit, electrical power, engine-driven generators, bleed air, thermal management, environmental control system

AF02-178 TITLE: Fuel Additives For Reduced Engine Emissions

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop innovative fuel additive(s) for JP-8 and JP-5 fuels that will reduce both the mass Emissions Index (grams of PM2.5 emissions/kilogram of fuel) and the number density Emissions Index (particle number density/kilogram of fuel) of PM2.5 in the exhaust of military gas turbine engines by 70 percent.

DESCRIPTION: Gas turbine engines and ground support equipment are a major source of soot particulates. Soot particulate emissions lead to increased engine and fuel system components maintenance costs, and decreased engine life and aircraft/engine availability. They contribute to haze and impair visual range. They also form nucleation sites for condensation and sites for complex chemical reactions that can lead to ozone depletion at high altitudes. Efforts to legislate air standards on a global scale are largely the direct result of the rise in emissions of oxides of nitrogen (NOx), carbon monoxide (CO), and unburned hydrocarbons (UHC). The National Ambient Air Quality Standards have a health-based regulation for particulate matter with diameters less than 10 microns (PM10). The regulation limits exposure to air with PM10 concentrations greater than 150 micrograms per cubic meter (μg/m3) in a 24-hour time period and an annual 24-hour exposure of no greater than 50 μg/m3 (EPA Fact Sheet Dated November 29, 1996). There is growing evidence that this regulation is insufficient to eliminate serious health and environmental problems for particulate matter with diameters under 2.5 microns (PM2.5). Indeed, the EPA has adopted a revision of the regulation for PM2.5 particles (EPA Fact Sheet dated July 16, 1997). Studies have shown that turbine engine exhaust is comprised of particulates less than 2.5 microns. Recent epidemiological studies in the U.S. and Western Europe report strong correlations between airborne particulates and human health. Moreover, particulate matter has also been linked to the formation of contrails and subsequently cirrus clouds; and hence, it can also affect climate changes and from an

operational point, survivability. Increased cloud formation has been identified as a contributor to global warming. National efforts to reduce emissions have focused on combustor design rather than on fuel chemistry/combustor interactions. However, recent experimental data has shown that additives can be used to reduce soot particulate formation. Particulate suppression via the use of additives may be effected via two paths: destruction of soot particulates once formed, or prevention of inception reactions. The latter offers a potential order for magnitude soot particulate reduction; hence it is desirable to develop and tailor jet fuel formulations to mitigate particulate formation. The goals for the additive are that it should: (1) be benign to the environment and safe to handle, (2) be low in cost (fractions of a cent per gallon of fuel); (3) be effective at low concentrations (ppm level); (4) not degrade the fuel performance specifications or combustion characteristics; (5) and not reduce engine performance and life. These goals seem reasonable when compared to the development of JP-8 +100 additive that currently costs $0.005 per gallon and is expected to decrease as volume increases. The +100 additive is present in the fuel at a concentration of 256 ppm by weight. It is desired to mitigate particulate formation without compromising performance. Reformulation of the fuel is not a viable option when one considers that it took 20 years for the military to transition from JP-4 to JP-8 fuel. Moreover, development of a reformulated fuel will be costly, and the resultant fuel (likely to be highly refined) may cost two to three times more than JP-8 or JP-5 (e.g., JP-7). We believe that the preferred approach is to use additives. The use of fuel additives is a pervasive and cost-effective approach that has the potential of reducing PM2.5 emissions in all engines in the fleet.

PHASE I: Demonstrate the feasibility of using fuel additives in JP-8 and JP-5 to reduce PM2.5 emissions from military turbine engines. Identify chemical compounds that potentially reduce PM2.5 based on chemical modeling and experimental assessments.

PHASE II: Continue development of fuel additives, and assess the performance of the most promising additives in a prototype combustor at conditions of interest to the Joint Strike Fighter (JSF) Program Office. Demonstrate additive effectiveness and optimize additive concentration. Conduct additive stability and material compatibility studies and perform modeling and simulation of additive and fuel chemistry to provide insight into the effects of the additive on soot formation and destruction.

PHASE III DUAL USE APPLICATIONS: Additives that mitigate the formation of particulate matter from military engines are very likely to be effective in commercial aircraft. Use of these additives in commercial aircraft could eliminate approximately 1.9 by 10^6 kg of particulate matter per year. This will provide cleaner air environments in airport surrounding areas, and will save airline companies millions of dollars in landing fees due to potential noncompliance of future local air quality standards. These additives (or others with similar chemistry) may also mitigate particulate matter from stationary and mobile diesel sources.

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KEYWORDS: Soot formation, jet fuel, fuel additives, aircraft emissions, particulate matter, pollutants

AF02-179 TITLE: Fuel Tank Compatible Oxygen Sensor

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: As military aircraft look for continually lighter and efficient methods of fuel tank protection from ballistic impact, the usage of OBIGGS (On Board Inert Gas Generation) is basically a ground-based operation. Regardless of the type of OBIGGS used, the final determination of performance is based upon the oxygen concentration of the output from the system into the fuel tanks. The key to determining this is a direct measurement of

the oxygen content of the OBIGGS product, Nitrogen Enriched Air (NEA). The problem with this type of system is that current technology only allows for the measurement of the NEA prior to its entry into the fuel tanks. The presence of hydrocarbon vapors and fuel splashing on the sensor surface, e.g., a surface coated with a sol-gel fluorescent dye, tends to rule out currently "known" measurement concepts of the oxygen concentration once it is in the fuel tanks. The environmental effects can be very important for a self-calibrating oxygen sensor.This project will involve a thorough research, analysis and demonstration of near-term developmental technology that can meet the stated intended need. Oxygen sensing technology has many wide ranging applications in the commercial industry (automotive, medical, etc.) and it is possible that the technology already available can be adapted for aircraft fuel tank oxygen sensing applications with some appropriate physical/chemical modifications.

DESCRIPTION: The F-22 initially planned to utilize a sensor that could measure the "quality" of the ullage; however, the design was forced to change due to a lack of a mature technology, and the time pressures of First Flight. Currently, the F-22 sensor only informs the pilot/maintainer if the Air Separation Module (ASM) is working properly, with the assumption that validation testing accomplished on the F-22 Fuel System Simulator validated the performance of the OBIGGS. The fuel tank ullage is very dynamic, and frequent/rapid changes in altitude can result in relatively large changes in the oxygen levels in the fuel tanks, regardless of the quality of air being supplied by OBIGGS. The capability to sense in real time multiple locations inside the fuel tanks will allow for the development of a true inert ullage.New aircraft like the F-22 and JSF rely heavily on system monitoring for diagnosis of health and maintenance projections. The sensors will be able to alert the maintainers to potential problems with the fuel ventilation system based on in-flight monitoring of the quality of the ullage in certain locations. The sensor will also provide a Safety benefit. For example, the F-22 OBIGGS is considered to be Safety Critical because it provides lightning protection for the Fuel System. An enhanced sensor capability would provide a greatly improved assessment of tank inertness for both peacetime and combat service.Additionally, the sensor may have applications to commercial aircraft. The potential exists for the airline industry to begin incorporating OBIGGS on commercial jets in light of such mishaps as the crash of TWA Flight 800. This Oxygen Sensor concept would have a direct impact on airliner safety.

PHASE I: This task will involve proof of principle research on oxygen sensing technologies that can satisfy the requirement for safe and reliable operation in the presence of hydrocarbon fuels including wetting of the sensor. The measurement technique/ or techniques can be based on electrical, optical, or other measurable physical properties of the proposed sensor, which can be self-calibrated in-situ. In order to allow for a successful transition to a prototype system demonstration in Phase II, the choice of the sensor should be justified to meet the following requirements.1. Power requirements2. Hardware requirements3. Software requirements4. ROM costs for EMD type development5. System weight estimates6. Expected Reliability and Maintainability impact 7. Feasibility dates of availability for flight-worthy systemModeling and simulation of the sensor system is encouraged so that there is a defined process for the decisions on trade-offs.

PHASE II: Design and test the top ranking candidate system to demonstrate the dynamic range and sensitivity limit of molecular oxygen detection. The test matrix should be compatible with the intended application. Also, the hardware design should permit incorporation/retrofit into the existing OBIGGS designs.Provide results of the study and the tests to the following customers for potential incorporation/retrofit into OBIGGS designs: F-22 (USAF), JSF (USAF/USN) and C-17 (USAF). Commercial aircraft may also be able to utilize this technology based on recent flight mishaps, and the potential for fuel tank inerting implementation.

PHASE III DUAL USE APPLICATIONS: Evaluate the fuel tank oxygen sensor application for both new and retrofit of commercial aircrafts.

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KEYWORDS:

AF02-181 TITLE: Fuel Tank Ullage Oxygen Sensor for Live-Fire Ballistic Testing

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: To design and develop innovative low cost oxygen sensor system for use in live-fire ballistic testing of aircraft fuel tanks.

DESCRIPTION: One of the cornerstones of assessing the survivability of current and future aircraft is live fire ballistic testing on actual aircraft hardware. A key area of concern is the ullage or head space of the aircraft fuel tanks. Fuel volatiles can mix with surrounding gasses to form potentially combustible mixtures. To ensure this does not occur, an inert gas is generated to fill the head space, thus reducing or eliminating the potential for ignition. A primary concern is the amount of oxygen present. Accurately measuring the oxygen content in actual aircraft fuel tanks, and in the test hardware, will ensure that realistic conditions are tested. The goals for this effort are to: (1) develop and demonstrate an accurate, low cost, long-life, nonflight weight prototype oxygen sensor for use in live fire destructive ballistic testing, (2) develop an innovative technique to determine the ullage oxygen content and assess the inerting capability of aircraft wing-tank systems, (3) incorporate the sensor and associated hardware within a C-5 aircraft wing-tank system, and (4) demonstrate the concept and assessment technique during live fire ballistic testing. Unique technical requirements are that the sensor: (i) size is limited to 8-inches length by 3-inches in diameter, (ii) maintain a minimum full-scale accuracy of 0.5 percent and a sensitivity of 0.1 percent over a range of 5-25 percent concentration oxygen, (iii) is immune to ambient temperature from -60 to 290 „aF, (iv) is capable of withstanding brief immersion within and repeated splashing by JP-8, JP-5 or Jet-A fuels and still maintain specified measurements after immersion, (v) stability is self-correcting using an onboard reference, (vi) system is capable of recording signals at a rate of two samples per second, with either automated signal processing, or postprocessing capability usable by a nonexpert and compatible with a PC computer. This effort is distinctly different from another topic that is focused on developing a long-life, flight-worthy oxygen sensor to be permanently installed in aircraft fuel tanks.

PHASE I: Design and demonstrate the feasibility of the low cost concept through subscale and/or full-scale component testing.

PHASE II: Fabricate and demonstrate a prototype of the proposed concept if not accomplished in Phase I.

PHASE III DUAL USE APPLICATIONS: This technology has application to both commercial and military aircraft markets. Lightning strikes and other mishaps, such as that which occurred with the crash of TWA flight 800, are growing concerns that can be addressed with this technology.

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KEYWORDS: Aircraft, ballistic testing, fuel tank, wing-tank, ullage, oxygen sensor

AF02-182 TITLE: Advanced Vibration Monitoring Diagnostics and Prognostics Techniques

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: To advance the current state-of-the-art for turbine engine vibration monitoring and health assessment

DESCRIPTION: Vibration monitoring is key to providing accurate health assessment of rotating machinery and is used successfully in many turbine engines used by air forces in other countires. Also, sophisticated vibration analysis techniques are being employed in helicopter usasge monitoring. However, due to high procurement and life-cycle costs, high maintenance costs, flight safety issues (especially false alarms), it is used sparingly on a limited number of turbine engines in the USAF inventory. Innovative ideas and solutions are required to provide a comprehensive vibration system that shows significant improvement compared to systems used today. The primary focus of this SBIR topic should be to use vibration accelerometers (or other sensors), data acquisition technologies and analysis techniques, and computerized algorithms, and apply these to vibration spectrum frequency ranges well above the normal broadband and 1 per revolution (rotational frequency) ranges the engine manufacturers typically use. Advanced vibration motoring capabilities developed and demonstrated by this SBIR topic should involve analysis of vibration frequency spectrum ranges at least up to 6 per revolution engine rotational speed, up through 40khz (acoustic frequency range) and even up through 100khz (ultrasonic frequency range). These advanced vibration monitoring diagnostic and prognostic capabilities must be targeted for on-board, real-time, and in-flight applications, and would become part of a comprehensive Engine Health Management (EHM)or Prognostic Health Management (PHM) system. This new vibration analysis capability will be used to develop and demonstrate an accurate predictive (useful life remaining) part of prognostics. The vibration monitoring system has to record, store, and sort the vibration data to provide a comprehensive vibration trace and health map for better engine management and configuration control. To this end, the system must be able to provide accurate diagnostics to the component level, and trending out to at least 20 hours, with no false alarms. This system must have the ability to interface or linked with servicing records and maintenance publications. It must provide a flexible vibration-monitoring solution for several engines with easy modification and integration, to include the engines for the JSF and larger engines such as the P&W F117 for the C17. For the future, the vibration system needs to be adaptable to be integrated into future PHM and EHM systems and should be capable of plug-and-play operation without special software or the need for experienced or specially skilled operators. As the research work on the Versatile Affordable Advanced Turbine Engines (VAATE), and especially the Intelligent Engine, gathers pace, this SBIR work will ensure the current engine fleets are appropriately managed and maintained to reduce life-cycle costs and the logistic footprint. It will improve understanding and visibility of engine health, extend engine time on wing, help maintain engine performance, and provide a comprehensive database to cater for continuing work on advanced diagnostics and prognostics.

PHASE I: Develop a vibration monitoring system for the analysis of vibration frequency spectrum ranges at least up to 6 per revolution (engine rotational speed) and up to 100khz for use on a large fleet of military aircraft engines. The system must be capable of recording and storing vibration scans and provide accurate diagnostics, and trending to at least 20 hours, with no false alarms. Demonstrate the vibration sensor and system capabilities and list the benefits that these will provide over the best competition, such as those in helicopter usage monitoring systems. A modeling and simulation approach is encouraged to guide the design, experiments, and subsequent tests. Indications of system and sensor cost must be provided.

PHASE II: Develop and expand the system using an open architecture and, where appropriate, commonly available hardware and software. This sytem will be demonstrated in a real world engine environment either in an engine test cell or on-wing (not necessarily in-flight but the system should be flight-capable). If the testing is conducted on the engine of an AF prime contractor or in the prime contractor's facility, such testing should be conducted at no cost to the SBIR program. Base upon these test results, the USAF will select the most appropriate engine on which to perform a Field Service Evaluation. The SBIR contractor will provide a cost benefit analysis for installation to the chosen engine fleet and determine the best implementation path. The implementation would occur under Phase III.

PHASE III DUAL USE APPLICATIONS: The vibration analysis and health monitoring system could be used on other turbine engines in use in the airline or small-business-jet commercial aviation industry, power and oil, or on other rotating machinery as used by the automobile and power industries. It has the potential to increase availability and operational effectiveness, and reduce time to diagnose faults. The global market for advanced multi-capable vibration monitoring is massive. Moreover, as the cost of new, more complex, machinery increases, health monitoring and asset management will become essential to keep life-cycle costs in check, and at the same time provide maximum availability and readiness of the equipment.

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KEYWORDS: Maintenance, data, analysis, vibration analysis, readiness, turbine engines, engine health monitoring, prognostics, diagnostics, predictive diagnostics, gas turbine engine health monitoring and health management.

AF02-183 TITLE: Small, Low Cost, High Performance Engines for Miniature Munitions

TECHNOLOGY AREAS: Weapons

OBJECTIVE: The development of a prototype engine, suitable for a small munition offering improved performance over currently available engines.

DESCRIPTION: With the increasing interest in small smart munitions and the developments in automatic target recognition (ATR), the need arises for the development of fuel efficient engines to power them over the battlefield. Low cost, fuel efficiency, and small size are key. Ideally, engine weight and fuel efficiency could be improved using new materials, or even through the application of novel engine cycles. Also applying some of the lessons learned from the successes in miniature machine technology, size and weight could be reduced. In addition, with advanced manufacturing and design methods cost could be lowered. Sizes of interest would be less than 6" in diameter and capable of generating 50 to 100lbs of thrust across a wide operating range while still delivering thrust specific fuel consumption of less than 1 (fuel specific impulse greater than 3600 seconds).

PHASE I: Identify the basic engine operating cycle, estimated performance, system limitations, size and weight of the engine and required subsystems, as well as system cost. The definition should be of sufficient detail to lead to the design, fabrication, and testing of a prototype engine (flight type, not necessarily flight weight) in the following phase.

PHASE II: Construct and test (in a relevant environment) a prototype engine, or a representative system to fully determine the ability of the engine to be built and operated. This would prove the feasibility of the concept and design. In addition, identify any new materials or manufacturing processes that would have to be further developed and implemented for production of the engine concept.

PHASE III DUAL USE APPLICATIONS: Military applications of this technology would be for the powering of small munitions, and possibly decoys and remotely piloted vehicles. Further, this type of engine could have use as small, auxiliary power unit. Uses in the civilian world could be for small reconnaissance vehicles for pipeline inspection, or inspection of hazardous areas. In addition, this small engine could be used in recreational remote control aircraft.

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KEYWORDS: propulsion, missile, turbojet, ramjet, pulse detonation, pulse jet, ducted fan, air turbo rocket

AF02-184 TITLE: Global Reach High-Speed air Vehicles and Weapons

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Reduce high-speed propulsion drag during sustained hypersonic flight with either plasma gas dynamics or controlled burning. Design techniques for reducing drag of high-speed propulsion systems using gas dynamics or controlled burning.

DESCRIPTION: At high speed, base area drag in and around the engine can significantly reduce propulsion and vehicle performance. Propulsion systems operating over broad ranges of Mach numbers and altitudes are particularly vulnerable. At transonic speeds, controlling flow separation and pressurizing base areas with burning can minimize base drag. At hypersonic speeds, where the thrust minus drag margin is small, reductions in drag will lead to large gains in vehicle performance. Novel propellant injection systems and controlled combustion within the propulsion path have the potential to reduce friction and to increase pressure in base regions. Novel techniques for injecting fuel or spent coolants at selected regions have the potential of significantly reducing induced drag. "Smart" sensors and actuators will be required.

PHASE I: Design drag reduction devices for reducing base and friction drag using plasma gas dynamics or controlled combustion for high speed vehicles (Mach range >4). Develop computational tools to simulate the effects of the drag reduction technologies, and define the experimental efforts necessary to validate these tools.

PHASE II: Incorporate drag reduction methodology into high-speed propulsion system designs; evaluate the impact on achievable vehicle range. Experimentally validate the analytical models developed in Phase I.

PHASE III DUAL USE APPLICATIONS: Computational tools and experimental efforts will result in more fuel efficient and long range high-speed aircraft as well as significant reductions in space-access costs for the next generation of launch vehicles.

REFERENCES:

1. Payne, M., Chrissis, J., Pohl, E., Bowersox, R., Gruber, M., Fuller, R., "Optimizing Scramjet Fuel Injection Array Design" AIAA 99-2251

2. Yungster, S., Trefney, C., "Computational Study of Single-Expansion-Ramp Nozzles with External Burning" AIAA 94-0024

3. Gurianov, E., Harsha, P., "AJAX: New Directions in Hypersonic Technology", AIAA 96-4609

KEYWORDS: combined cycle engine, ramjet, scramjet, supersonic inlets, supersonic nozzles, increased range, drag reduction, fuel efficiency,

AF02-185 TITLE: Technologies for Air Breathing Propulsion

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Explore innovative approaches for air breathing propulsion systems for manned and unmanned applications.

DESCRIPTION: The Air Force Research Laboratory's Turbine Engine Division aggressively pursues major performance advances in all components for Department of Defense aerospace propulsion. Technologies are assured relevant demonstration and transition through coordination with the Integrated High Performance Turbine Engine Technology (IHPTET), High Cycle Fatigue (HCF) and Versatile Advance Affordable Turbine Engine (VAATE) initiatives. Technologies derived under these initiatives have resulted in higher thrust-to-weight ratios and improved efficiencies. The focus of this topic is to consider concepts that enhance the performance of gas turbine engines and other aerospace propulsion systems that could support manned and unmanned mission requirements. Concepts are desired to advance the current state of the art of technologies utilized for aerospace propulsion. Such applications include, but shall not be limited to, control technologies for increased performance and durability in gas turbine engines, composites for bearings, smart ceramic matrix composites (CMC) materials, advanced instrumentation, advanced turbine testing and analysis techniques (e.g. probabalistics). A strong need exists for high temperature sensing (up to 1300 degrees F for the compressor, 3000 degrees F for the turbine, and 4500 degrees F for the combustor). Sensor/actuation concepts may involve the use of microelectromechanical systems (MEMS). Such concepts should address packaging and durability issues. Other topics of interest include forced response, pulsed-detonation systems, combustion systems, turbine heat transfer and performance, component durability, and engine affordability.

PHASE I: Define the proposed concept and predict the performance of the proposed design. Explore the feasibility of the concept and demonstrate the merits of the design through analysis or small-scale testing.

PHASE II: Provide prototypical device, hardware demonstrations, or detailed analytical modeling.

PHASE III DUAL USE APPLICATIONS: Historically a large majority of the technology developed under the Integrated High Performance Turbine Engine Technology (IHPTET) Program has transitioned to military and civilian aviation systems. Technology that increases engine performance while enhancing durability and affordability will be enthusiastically considered for inclusion in upgrades or initial designs of engine systems.

REFERENCES:

1. http://www.pr.wpafb.af.mil/ (click on "Technology Thrusts" then "turbine engines")

2. http://www.aircraftenginedesign.com/links.html

KEYWORDS: gas turbine engines, propulsion, durability, affordability, instrumentation, IHPTET.

AF02-186 TITLE: High Heat Flux Laser Diode and/or Solid State Laser Cooling for Airborne and/or Spaceborne Directed Energy Applications

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop advanced cooling technology and thermal management techniques for airborne and/or spaceborne high power solid state and/or diode laser devices with high heat fluxes.

DESCRIPTION: Many of the state of the art laser diodes and solid-state lasers currently use cooling systems that are limited to less than 100W/cm2. Significant improvements in the heat flux capabilities of the thermal management system would allow these devices to be much more compact. Better cooling and load leveling during periods of peak usage will make these devices suitable for many more airborne and/or spaceborne applications. Through the use of advanced high-heat flux cooling techniques such as (but not limited to) spray cooling, jet impingement cooling, microchannel cooling, or porous metal cooling, the heat flux can be increased to 500-1000W/cm2 enabling significant improvements in the device output power, size and mass. Innovative cooling techniques are sought, scaleable to high power applications and suitable for airborne and/or spaceborne applications with the associated acceleration and vibration conditions.

PHASE I: This feasibility phase of the project should demonstrate the high-heat flux capability of the cooling technique proposed and establish a preliminary design for integrating the thermal management with the laser diode device. Modeling and simulation will be used to estimate the benefits of the improved cooling and the scalability.

PHASE II: This phase of the program should include the detailed design, fabrication and testing of proof-of-principle hardware integrated with the laser diode device.

PHASE III DUAL USE APPLICATIONS: The approaches developed to cool this very high flux power source may have commercial and industry applications in utilities and large-scale manufacturing facilities.

REFERENCES:

1. Huddle J., L. Chow, et al, "Advantages of Spray Cooling for a Diode Laser Module", SAE Power System Conference, October 31-November 2, 2000, San Diego, CA.

2. Sumida D., A. Betin, H. Bruesselbach, R. Byren, S. Matthews, R. Reeder, and M. Mangir, "Diode-pumped Yb:YAG Catches Up With Nd:YAG," Laser Focus World, pp. 63-70, June 1999.

KEYWORDS: directed energy weapons, laser diode cooling, thermal management, high-heat flux thermal management

AF02-187 TITLE: Ultra-wide bandwidth high-power solid state photoconductive power switch technology

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a high-voltage (10-20 kV) high-current (50-200 Amps) solid state photoconductive power switch with subnanosecond rise time.

DESCRIPTION: In many Air Force applications, such as radar drive circuits, directed energy weapons (DEW), plasma cloaking, and other electrical high peak-power systems for manned and unmanned aerospace vehicles, the availability of a compact and reliable ultra-wide bandwidth, high-voltage, high-power switch can become an enabling technology.

Currently available high voltage switches for such applications, rely on thyratrons, krytrons, and spark gaps. The replacement of these vacuum devices with a low-jitter, high-speed photoconductive switch can significantly reduce cost, volume, the weight of pulse forming networks (PFNs), and also improve reliability. In order to achieve low-cost, highly reliable operation of a ultra-wide bandwidth high-power photoconductive switch, it will be required to develop a device which can operate near its bulk dielectric breakdown strength and also avoid current constrictions or filamentations. The high-speed low-jitter requirements can be satisfied by suitable choice of a direct band gap semiconductor material such as GaAs, or SiC. Research needs to be conducted to develop a heterostrucure or other metal-insulator-semiconductor structure device to alliviate near-surface dielectric breakdown caused by the onset of current filamentation well below the bulk dielectric breakdown strength of the material.

PHASE I: Assess device structure through modeling and a feasibility test of a high-voltage photoconductive switch to demonstrate improvement of the current filamentation formation threshold. Total system requirements should be defined for a packaged switch.

PHASE II: Design, develop, and demonstrate a prototype high-power, ultra-wide bandwidth solid state photoconductive power switch suited for radar drive circuits or plasma cloaking.

PHASE III DUAL USE APPLICATIONS: Aircraft and automotive ignition systems, chemical/biological agent or materials destruction using atmosphereic pressure plasmas.

REFERENCES:
1.K.M. Mayer, R. P. Huebener, and U. Rau, "Nucleation and growth of current filaments in semiconductors", Journal of Applied Physics 67, pp 1412-1416 (1990).

2. U.S. patent number 5,811,841. 3. Twenty-fourth International Power Modulator Symposium, June 26-29,2000, Norfolk, VA.

KEYWORDS: Photoconductors, direct bandgap semiconductor, high-power solid state switch, pulsed power, dielectric breakdown, space-charge,

AF02-188 TITLE: Health Monitoring for the Integrity of Electrical Power Wiring and Power System Components

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop techniques that enable the evaluation of electrical power system integrity and health monitoring for insulation systems, wiring, interconnections, and passive or dynamic loads for space and air (high altitude) vehicles.

DESCRIPTION: This topic addresses advanced and innovative concepts for monitoring the integrity of aerospace electrical power systems, including insulation systems and component or subassembly status, to detect incipient failures and, therefore, prevent subsequent breakdowns. The diagnostic techniques developed under this topic would enable the technologies necessary for monitoring the operational readiness of low-maintenance or unattended systems in manned and unmanned aerospace vehicles or orbiting platforms. In addition, the technologies developed under this topic would be important for compact electrical high power systems for critical technology areas such as directed energy applications, advanced surveillance systems, and electric propulsion applications. Power electronics in aerospace equipment may have to operate continuously at subatmospheric pressures. Operational integrity must be assessed with emphasis on discharge problems or high impedance faults due to a variety of factors, such as: high electric field stress with higher operating voltages, lower voltage breakdown characteristics due to the low pressure or space environment, derated breakdown thresholds at intermediate power switching frequencies (10 kHz to 1 MHz). The research should focus on offline methodology for component QC (quality control) and certification, as well as, for in-flight/in-space monitoring of system operation. During offline evaluations, sensors and detection systems must be capable of operation in a low pressure (less than 0.1 torr) environment of atmospheric and inert gases. Diagnostics may be tailored to specific, critical system components, to extend useful operational life via predictable, incipient failure indicators. To be non-invasive, sensors may need to be made a part of the device, without disturbing its electrical or mechanical characteristics. Regardless, the detection methodology must be capable of calibration via a standard technique, for potential incorporation into international test standards. Methodologies based on mature techniques such as continuity testing, hipot testing or conventional corona testing will not satisfy the innovative criteria. For the online, in-operation systems diagnostic case, progress has been made in the development of differential current monitors, ionization detectors, thermal sensors, miniaturized acoustic transducers, and small optical detectors. Hence, it is possible to consider the application of data fusion methods, correlation analyses, and adaptive algorithms to predictive health

monitoring of electrical power systems or components. It is reasonable to assume that multisensing methodologies will lend themselves more readily to critical, isolated power components or enclosed subassemblies. The development of such schemes for subassemblies could eventually enable the development of a Built-In-Test (BIT) sensor system with appropriate signal conditioning and data analysis as an integral part of the power management system. However, the offline methodology must be demonstrated before the technique can be viably incorporated into an online, in-operation system diagnostic. Finally, the research should focus on providing diagnostic techniques for high reliability, high mean-time-between-failure (MTBF) systems for space and air (high altitude) vehicle electrical power where weight, volume, packaging and environmental constraints are major factors.

PHASE I: Develop a detailed technical definition of the problem, consider potential solutions, identify and justify a preferred proposed solution, and demonstrate the key technologies enabling the use of that solution. Techniques proven first for offline monitoring and qualification may prove effective for applications requiring on-line diagnostics. (It is presumed that systems requiring monitoring in-operation will likely go through offline QC as well.) The technique or method should be demonstrated in a working prototype, as a minimum. A physical-electrical model and simulation is encouraged to guide approaches and solutions, but is not sufficient to satisfy Phase I goals, by itself.

PHASE II: Iterate on research to resolve any remaining problems discovered from model and prototype and then concentrate on development of operational designs for components, subsystem demonstrations, hardware and software development.

PHASE III DUAL USE APPLICATIONS: The technologies developed under this topic can be transitioned to commercial aircraft, space satellites, reusable launch vehicles and terrestrial facilities that must operate in a sub-atmospheric environment.

REFERENCES:

1. More Electric Aircraft Goals, Air Force Research Laboratory Web Site,http://www.pr.wpafb.af.mil/divisions/prp/programs/mea/mea.htm

2. Proceedings, Electrical Insulation Conference and Electrical Manufacturing and Coil Winding Conference, Cincinnati, OH, October 1999

3. Proceedings, 23rd International Power Modulator Symposium, Rancho Mirage, CA, June 1998.

4. Proceedings, IEEE International Symposium on Electrical Insulation, Baltimore, MD, June 1992.

5. Proceedings, IEEE International Symposium on Electrical Insulation, Anaheim, CA, April 2000

KEYWORDS: Electrical Power Systems, Insulation, Sub-atmospheric Environment, Integrity, Reliability, Diagnostics, Interconnections, Components

AF02-190 TITLE: Improved Composite Front Frame for Weight and Cost Reduction

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: To demonstrate that the front frame of a typical modern jet engine can be produced using techniques such as braiding and Solvent Assisted Resin Transfer Molding (SARTM).

DESCRIPTION: The Joint Strike Fighter (JSF) F120 engine faces the challenge of maintaining high performance while reducing weight and cost. Using a composite front frame would save about 30 pounds, compared to the titanium alternative. However, conventional composite manufacturing is very labor intensive, expensive and has varying quality. A potential solution is to use an automated processing technique such as braiding. Braiding is a traditional textile process that automatically places high performance fibers into the composite parts. In addition to the braiding, Solvent Assisted Resin Transfer Molding (SARTM) can be used to reduce the manual labor. SARTM is a proven process with proven materials with temperature capabilities up to 350 degrees F. There are several challenges for the JSF F120 engine front frame. It has a design requirement of 475 degrees F due to the anti-ice system. This frame must also remain structurally viable for impact loads and unbalanced loads due to blade out, while addressing the goal of 10% weight savings and 15% cost savings over conventional hand lay-up composite frames by using automated methods). Innovative approaches are sought to incorporate these types of techniques, so that issues related to a full-scale, functional, lightweight, high temperature, low cost design can be resolved.

PHASE I: Phase I will perform research on issues related to defining the manufacturing process, perform modeling and simulation for analysis of alternative designs and processes while Phase II will concentrate on developing and validating the selected manufacturing processes. During Phase I tasking, the manufacturing process will be defined using cost/process trade studies. A physical system model should guide the approach selected. Also, initial attachment features for a full-scale front frame structure will be researched and high risk/critical issues associated with the manufacturing process will be identified and solutions outlined.

PHASE II: Using the results of Phase I and initial design parameters (ref 4), the specific details of manufacturing a front frame will be researched and accomplished. These details include, determining material specifications, defining preform constructions, developing initial tooling, developing manufacturing automation methods, and developing nondestructive evaluation techniques. The manufacturing processes will be validated using structural analysis, material properties characterizations, subcomponent testing, and full-scale testing.

PHASE III DUAL USE APPLICATIONS: This technology will benefit both the military and commercial engine businesses. The materials and processes developed and verified in this program can be used in any design in which strong and lightweight material, operable up to 475 degrees F, is applicable, including land based turbines and airframe structures.

REFERENCES:
1. "Low Cost Processing of High Temperature Polyimides", Proceedings: 31st International SAMPE Technical Conference; Salemme, Charles; Armstrong, Douglas; Sargent, Kathleen; 26-30 October 1999.

2. "Assessing Competitive Strategies for the Joint Strike Fighter: Opportunities and Options", Report Number RAND-MR-1362.0-OSD/JSF, ADA390514; Birkler, John; Graser, John C.; Arena, Mark V.; Cook, Cynthia R.; Lee, Gordon; March 2001.

3. "The Next Generation Attack Fighter: Affordability and Mission Needs", Report Number RAND/MR-719-AF, ADA327531; Stevens, Donald; Davis, Bruce; Stanley, William; Norton, Daniel; Starr, Rae; 1997.

4. "JSF F120 Engine Program. Low Cost Operation and Support. An Engine Manufacturer's Perspective", Applied Vehicle Technology Panel (AVT) specialists' Meeting, Ottawa, Canada; Murphy, K.; Smith, J.; Wensits, D.; 21-22 October 1999; ADP010426.

KEYWORDS: Turbine Engine Frames, Polymeric Matrix Composites, Resin Transfer Molding, Fiber Braiding, Composite Processing, High Temperature Resins

AF02-191 TITLE: Advanced Rocket Propulsion Technologies

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop innovative components, manufacturing and processing techniques, and integration technologies aimed at doubling existing rocket propulsion capabilities by the year 2010.

DESCRIPTION: There is a critical need for novel, innovative approaches to develop technologies that can double existing rocket propulsion capabilities by the year 2020, and for new, nonconventional aerospace propulsion-related technologies that will revolutionize aerospace propulsion in this century. These revolutionary concepts, based on sound scientific and engineering principles, are essential in order to increase performance and mission capability while either maintaining or decreasing existing life-cycle costs. The proposed solutions shall emphasize "dual use technologies" that clearly offer civilian/commercial as well as military applications. Proposals emphasizing "spin-on technology transfer" from the civilian/commercial sector to military applications will receive additional consideration. Our technological goals are intended to exceed the improvements expected to be realized by current programs, such as the Integrated High-Payoff Rocket Propulsion Technologies (IHPRPT) program. Examples of achievements at this level include: (1) Improve specific impulse and mass fraction for boost and orbit transfer, spacecraft, and tactical missile propulsion by more than 40% over current state of the art (SOA). (2) Reduce the stage failure rate by 2X. (3) Reduce hardware and support costs for boost and orbit transfer propulsion by more than 80% and 40% over SOA, respectively. (4) Improve the thrust-to-weight ratio for liquid rocket engines by more than 100% over SOA. (5) Improve the total impulse to wet mass ratio for electrostatic and electromagnetic satellite propulsion systems by 80% and 1000% respectively. (6) Improve density impulse of monopropellants for satellite propulsion systems more than 80% over SOA. (7) Improve the delivered energy of tactical missile propulsion systems more than 20% over SOA. In the conduct of rocket propulsion research, we strive to reduce environmental hazards from propellant ingredients and processing, propulsion exhaust, and rocket motors while either maintaining or surpassing current propulsion efficiency.

Improvements in the operability, reliability, maintainability, and affordability of space launch applications, for example, might include development of novel systems which can be launched with short lead times for relatively low life-cycle costs. An example of such a concept may include the design and development of a rocket-based combined cycle (RBCC) engine. Such systems would need to demonstrate high reliability and maintainability levels. Subsets of advanced rocket technologies would have lengthy shredouts of potential research subjects but are not stated here in detail. These technologies might include performance sensors, performance predictions, modeling of exhaust plume radiation and combustion characterization, propellant and component service life prediction technologies, and environmental contamination. New advanced propulsion and related technological concepts and products for space activities are solicited for development. The topics include revolutionary concepts in advanced fuels and oxidizers, metastable high energy nuclear states, storage of antimatter in chemical matrices, nanotechnology products and techniques applied to rocket propulsion, enigmatic energy devices, and field propulsion thrusters. Research in these advanced rocket propulsion topics is included and structured to provide a maximum of innovative flexibility while yielding promising commercial applications/dual-use technology applications for prospective investigators. Proposals also submitted for any other Department of Defense FY02 Small Business Innovative Research (SBIR) topic shall not be considered for this topic.

PHASE I: Further research and develop the concept and perform analyses required to select approaches and to establish the feasibility of the proposed approaches. Modeling and simulation are encouraged to track the analyses of alternatives.

PHASE II: Complete the Phase I design and develop technologies for a demonstrator or prototype. Provide predictive performance analyses. Define reliability and manufacturability of chosen approaches. Develop a technology transition and/or insertion plan for future systems and commercial ventures.

PHASE III DUAL USE APPLICATIONS: Advanced rocket propulsion technologies will transition to new, higher performing and/or lower cost U.S. military and commercial rocket engines and motors or advanced propulsion systems. This will enable the U.S. aerospace industry to increase global market share for space launch opportunities by reducing the life-cycle cost and increasing the efficiency of inserting payloads in orbit. Advanced rocket propulsion technologies also serve the commercial sector by enhancing our ability to remanufacture components to maintain and monitor the health of the U.S. ballistic missile fleet.

REFERENCES:

1. 1998 JANNAF Propulsion Meeting Proceedings Volume 1, Cleveland OH 15-17 July 1998. Chemical Propulsion Information Agency CPIA-PUB-675-VOL-1;(DTIC AD-A354191)

2. Air Force Research Laboratory Propulsion Directorate website address: http://www.pr.afrl.af.mil

3. Tuffias, Robert H. et al., "Advanced material for solar-thermal propulsion"; Proceedings of Solar Engineering 1992, 5-9 April 1992, Maui HI USA, pp 783-786, ASME; New York, NY 1992, ISBN 0791807622

4. Stanley, D. O. et al., "Propulsion System Requirements for Reusable Single-Stage-to-Orbit Rocket Vehicles", Journal of Spacecraft and Rockets, Vol. 31, No. 3 1994, pp 414-420

5. Morris, W. D., et al., "Defining Support Requirements During Conceptual Design of Reusable Launch Vehicles", AIAA-95-3619, Presented at the AIAA 1995 Space Programs and Technologies Conference, Huntsville, AL, Sep 26-28, 1995

KEYWORDS: Rocket Plume, Rocket Engine, Rocket Propellants, Satellite Propulsion, Boost Transfer, Orbit Transfer

AF02-192 TITLE: Air-slew Package for Air-launched Missiles

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop solid propellant maneuverability packages for use on air-launched missiles and compact spacecraft systems

DESCRIPTION: Technology is required to develop a compact, self-contained thruster system for add-on use on air-launched missiles, satellite systems, and other high-maneuverability needs. This type of slew motor technology does not currently exist due to the unique combination of requirements, including small size and weight, short action time, compact packaging volume, and possible requirements for thrust vector control. These systems could be used to rapidly re-orient air-launched missiles, increasing rearward coverage by eliminating the need to use fuel from the main motor

to execute a large radius turn to the rear or employed as long-life stable maneuverability thruster for satellite systems. Innovative solutions to the various technological issues are required to demonstrate the feasibility of this type of system. These issues include, but are not limited to, propellant formulations, mechanical properties, ballistic requirements, ignition properties, and slew motor grain geometry. In addition, the aerodynamic and structural loads imposed on the system under this type of maneuver are unknown and must be investigated for their effect on missile integrity and flight dynamics. Modeling and simulation efforts, as well as small scale propellant and structural testing, are encouraged to guide the development of these technologies.

PHASE I: Perform research to demonstrate the feasibility of development of a compact add-on maneuverability system. Analyze several candidate motor configurations and assess the capability, risk, and payoff for each candidate. An air-slew package for maneuverability of a seven-inch diameter air-launched missile system is recommended as a prototype development baseline. Performs modeling and simulation to determine operational parameters and performance sensitivities.

PHASE II: Based upon the technology and designs developed in Phase I, further develop and test prototype slew devices to assess their performance, advantages, and disadvantages. Demonstration of the prototype systems' ability to meet the large offboresight/high maneuverability requirements of an air-launched system through the use of inert missiles or other viable analogs is encouraged.

PHASE III DUAL USE APPLICATIONS: This technology has direct application not only to the military applications for air-launched missiles, but also to rapid maneuverability needs for military and civilian satellite systems, orbital injection motors, and high delta-V maneuvers for interplanetary probes. This type of technology could also apply (either spinning-off or spinning-on) to automotive air-bag systems and other related safety mechanisms.

REFERENCES:
Jensen, Gordon E. and Netzer, David W., eds., "Tactical Missile Propulsion," AIAA Progress in Astronautics and Aeronautics vol 170, Chapter 6, AIAA, 1996., Chapter 6, 1996 Zarchan, Paul, ed., "Tactical and Strategic Missile Guidance," AIAA Progress in Astronautics and Aeronautics vol 124, AIAA, 1990. Sutton, George Paul, "Rocket Propulsion Elements: An Introduction to the Engineering of Rockets," Wiley, 1992.

KEYWORDS: air-slew missile, missile slew, aircraft defense, maneuverability, tactical missile, air launched missile, air-to-air missile

AF02-193 TITLE: Significant Improvements in High Temperature Resins for Solid Rocket Motor (SRM) Boost and Orbit Transfer Composite Cases

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: The development of a new high temperature resin and demonstrated compatibility with a sustainable fiber for SRM Boost and Orbit Transfer casing.

DESCRIPTION: The successful completion of the Phase III IHPRPT (Integrated High Payoff Rocket Propulsion Technology) goals for Solid Rocket Motor Boost and Orbit Transfer will result in a doubling of the capabilities of benchmark systems. In order to succeed systematic improvements of every component area are required including a dramatic increase in the Tg of current resin systems that are used for composite cases. The resin system is only limited to demonstrated sustainability (e.g., various uses in industrial marketplace) and must have a glass transition temperature (Tg) greater than 750 degrees F with a fiber stress at failure of greater than 700 Ksi at the desired temperature. Complete resin characterization of the polymer system (thermal, mechanical, electrical, physical properties) should be followed by resin/fiber compatibility studies and small pressure bottle fabrication and testing. Although pressure bottle testing is strongly en-couraged, if cost constraints are an issue, less expensive means to demonstrate Phase I success will be considered. Preliminary cost and weight reduction analysis relative to Phase III goals, commercialization efforts, and tie-in to rocket component leads are critical and should be included in the proposal. Innova-tive programs will look at ways exceeding the minimal temperature and pressure requirements.

PHASE I: The development of a >750 degrees F resin, demonstrating high translational efficiency, and small pres-sure bottle testing at use temperature.

PHASE II: The modeling, optimization, scale-up, and sub-scale testing (by Rocket Community) of pressure bottles under various temperatures. A complete program will integrate the use of the new resin for a SRM demonstrator and show transition pathways prior to the end of the Phase II SBIR.

PHASE III DUAL USE APPLICATIONS: The end product will be a new resin that will not only have applications for Propulsion Technology, but also be used in a variety of commercial applications where high temperatures (>600 degrees F) and pressures usually prevents the use of composites.

REFERENCES:
1. "Evaluation of PBO Fiber in Pressure Vessels," Humphrey, W.D., Vedula, M., 40th Int. SAMPE, May 8-11, 1995.

2. "High Temperature Tensile Properties of Graphite Fiber -Phthalonitrile Composites," Jones, H.N.,Keller, T.M., 2000 NSMMS Proceedings, 27 Feb-2 March 2000.

KEYWORDS: Materials, Resins, Rockets, Casing, Composites, Fibers, Polymers, Thermosets.

AF02-194 TITLE: Determination of Composite Motor Case Damage

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Design and verify a sensing method capable of accurately assessing damage to solid rocket motor composite cases.

DESCRIPTION: Composites are excellent materials for use in solid rocket motor cases due to their high strength and low weight. However, because they are fibrous, damage may occur during manufacture or transport that is not easily detectable and may significantly weaken the case. Breaking of the fibers, damage to the matrix, and delaminations of the plies are examples of the types of damage and defects that may occur. A sensing technique or device is needed for commercial and military solid rocket motors. It must be capable of detecting the location, extent, and type of damage that may have occurred in sufficient detail that an accurate assessment can be made of the motor's health and ability to perform the mission. Because there is a need to examine already fielded systems as well as those newly manufactured, sensors which would be embedded in the composite structure or require modification to the manufacturing process are not desired. An ideal system would require minimal (or no) physical contact between the sensor and the composite structure and would preferably be portable, although sensor networks which can be applied to the surface of the structure and remain with the system over its useful life will also be considered.

PHASE I: Develop and demonstrate a prototype system capable of assessing damage to composite materials. Demonstration articles should include typical aerospace composite materials (e.g. kevlar and graphite systems) and should be able to demonstrate the ability of the system to assess damage quantitatively (size and type of flaw, location and extent of damage, etc.).

PHASE II: Design and manufacture a subscale composite motor case design on which to demonstrate the prototype case damage system. Verification articles should be damaged or manufactured with known flaws similar to those in large motor cases. The accuracy of the damage detection system should be verified by comparison with current (e.g. destructive) means of testing. In order to show the technique is applicable to real systems, verification articles should include loaded (inert) subscale cases.

PHASE III DUAL USE APPLICATIONS: Composite materials are becoming prevalent in industry, particularly in various aerospace applications, due to their low weight, high strength, and good thermal properties. A system such as this would find many applications in the manufacture, maintenance, and repair of commercial and military aircraft, as well as spacecraft applications.

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KEYWORDS: Composite materials, composite damage, delamination, composite fiber, damage sensors, health monitoring

AF02-196 TITLE: Multi-Sensor Data Exploitation Capability

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a multisensor sensing, processing, fusion and exploitation capability to support detailed parametric electronic signature collection, mission planning and sensor tasking, onboard sensor management, and onboard and postmission data exploitation.

DESCRIPTION: The rapid collection and exploitation of complex electronic threat-emitter parametric information is critically important to supporting several Air Force operational missions. Currently, this type of data is independently collected by space, air, and ground-based systems within a stove-pipe architecture involving very little collaborative information sharing across systems. In today's high-tempo force deployment and employment scenarios, advanced strike and support platforms are attempting to use this type of data in real-time to support ongoing force employment missions. The need to optimize complex electronic threat-emitter parametric information collection, fusion, exploitation, and timely reporting is identified by the tactical air forces as a mission support shortfall. This shortfall is the result of a fundamental lack of understanding of the fusion phenomenologies at the sensor physics level for each of the candidate active and passive sensor modes being considered. The Air Force is seeking innovative solutions to this problem. Elements of the problem include a study of the fundamental sensor physics, intrinsic target signature characteristics (information theoretics), information requirements management; information-theoretics based sensor tasking and cueing; mission planning, data collection, processing, and fusion; and onboard as well as offboard data exploitation and reporting. Instead of a collection of stove-piped sensor systems collecting and processing information independently of other sensor systems, a system-of-sensor-systems architecture in which communications and information sharing within a network-based or centric collaborative infrastructure solution is needed to address this problem. Moreover, this capability should provide situation awareness with respect to over- and near-the-battlespace all-source sensor and force employment operations.

PHASE I: Phase I will create a concept of operations for the proposed capabilities, technical specifications, and some prototyping of key functional elements from a system-of-systems perspective. A fundamental analysis of the sensor physics and the resulting target signature information content (information theoretics) is needed for candidate active and passive sensor systems such as Ground Moving Target Indication (GMTI), Synthetic Aperture Radar (SAR), High Range Resolution (HRR), Inverse SAR (ISAR), and Electronic Signature Measurement (ESM). Assuming that these are stove-piped sensor architectures, the next stage of the feasibility study is to investigate at the information theoretics level, the fusion process leading up to exploitation. Specifically, each sensor system

PHASE II: Phase II will create a prototype which simulates a God's Eye situational awareness of the operational problem environment.

PHASE III DUAL USE APPLICATIONS: Phase III will involve the design, development, and testing of an advanced prototype with interfaces to existing or new sensors and sensor systems. Commercial Potential: The technologies developed will have multiple commercial applications including firefighting, natural resources management, and agricultural crop estimation and flight traffic control.

REFERENCES:
1. Edward Waltz, James Llinas, "Multisensor Data Fusion," Artech House, 1990;

2. Yaakov Bar-Shalom, "Mutlitarget-Multisensor Tracking: Applications and Advances," Artech House, 1992.

KEYWORDS: Information fusion, data fusion, multiintelligence fusion, multisensor fusion

AF02-197 TITLE: Digital Beamforming Transmit Subarray With Waveform Agility

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Design a digital beamforming transmit-only subarray antenna that can rapidly synthesize a variety of digital communication waveforms at different data rates.

DESCRIPTION: Commercial CDMA and military spread spectrum digital communication systems that employ phased array antennas can benefit significantly from the use of digital beamforming (DBF) in their transmit mode of operation. DBF enables simultaneous multiple beams without loss of signal–to-noise performance, and permits far greater spatial diversity than conventional analog multi-beam array antenna systems. On transmit, DBF arrays require rapid, highly agile generation and coding of the signature waveform shape, phase, and frequency, as well as up-

conversion, filtering, and amplification circuitry. The goal of this project is to develop and demonstrate a prototype DBF transmit-only subarray antenna system using novel waveform synthesis techniques and commercial-off-the-shelf (COTS) components. As a design goal, the DBF transmit subarray should consist of at least 4 x 4 elements fed by a single digital channel. Techniques for rapid generation and encoding of digital waveforms should be demonstrated through a combination of waveform synthesis algorithms embedded in digital hardware, and other hardware including D/A converters or Direct Digital Synthesis (DDS) chips, and microwave mixers, filters and amplifier circuitry.

PHASE I: Phase I activity shall include the following key tasks: 1) Investigate and compare the performance of current COTS D/A converters versus DDS devices, with emphasis on maximizing waveform diversity and waveform switching speed. 2) Develop waveform synthesis algorithms and techniques that enable rapid generation and switching between a variety of orthogonal digital modulations. 3) Design a complete DBF subarray transmit channel implemented using either D/A or DDS chips, coupled with programmable digital circuit components such as FPGAs, buffers, and control logic. In the design, also include all RF and microwave hardware necessary for transmit mode radiation, including mixers, filters, amplifiers, and antenna elements. 4) Design and model the performance of an array antenna comprised of at least 16 such subarrays. Strong emphasis should be placed on computer-based validation of a single subarray digital channel, and then the complete 16-channel array, using measured performance data obtained experimentally from actual D/A or DDS hardware.

PHASE II: Develop an operational prototype of a single channel DBF transmit subarray system. Use the DBF transmit subarray prototype to experimentally demonstrate generation of at least three different orthogonal digital communication waveforms, demonstrate at least two different data rates above 10 kbits/s, and demonstrate rapid switching between all the waveforms and data rates. Emphasis should be placed on measuring and quantifying the fidelity of the generated waveforms including signal-to-noise ratio, bit-error-rate performance, and microwave dynamic range. As a design goal, subarray performance should meet the current state-of-the-art.

PHASE III DUAL USE APPLICATIONS: A digital beamforming transmit mode array with waveform agility will be extremely useful for satellite-to-satellite, satellite-to-airborne, and satellite-to-ground communications systems. Such a system would potentially lower the costs of transmit terminals for both military and civilian applications, and stimulate the use of waveform diversity with spatial diversity in communication systems. Military applications include communication systems at S-band, and certain Extremely High Frequency bands. Civilian applications that would benefit from this technology include mobile/stationary ground terminals for commercial ground-based CDMA systems and satellite-based global communication systems for business/home use.

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KEYWORDS: Digital Beamforming, DBF on Transmit, Waveform Agility, Phased Array Antenna, Direct Digital Synthesis, D/A converter

AF02-198 TITLE: Improved Inertial Reference Transfer Unit (IRTU) - Gyros, Mounts, Models

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Improve inertial reference unit (IRU) accuracy at the system or component level.

DESCRIPTION: Develop enhanced performance and superaccurate inertial measurement capability. The accuracy and stability of inertial references allow precise aiming and navigation of weapon systems. Most current state of the art inertial reference units use the highly accurate fiber optic gyroscope. Because of relatively longer path lengths (~1 kilometer), high degrees of accuracy (<0.001 deg/hr bias stability) may be achieved. Indeed, angular random walk error

of a few thousandths of a degree per root-hour, are available in commercial designs. Reducing errors like these and those caused by temperature sensitivities offer potentially super accurate inertial measurements. Likewise, the mounting hardware and environmental sensitivities of the supporting electronics have an effect on the inertial reference unit's performance. They, along with the unit's control software, can either enhance or diminish performance. Reductions in size, power and cost and enhanced reliability are also goals for this IRU.

PHASE I: Define the proposed IRU system concept, specific system requirements, and predict the performance of the proposed design. Demonstrate basic system concepts in a laboratory or simulation environment.

PHASE II: Develop and fabricate a breadboard system and perform a laboratory demonstration to mutually agreed performance parameters. Demonstration of the IRU must be capable to support ground demonstration in a government facility and an airborne experiment. The prime consideration is deliverable system hardware and a demonstration of integrated system that performs well over the expected environments and has the potential for a 20-year lifetime.

PHASE III DUAL USE APPLICATIONS: This development of enhanced performance and super accurate inertial measurements will be used by multiple DoD programs involved with the navigation of weapon systems. The accuracy and stability of inertial references allow precise aiming and/or navigation for commercial applications such as telescope systems and sea, land, air, and space vehicles.

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KEYWORDS: Fiber Optic Gyroscope, Inertial Reference Unit, Inertial Navigation System, Navigation of Weapon Systems, Degree Per Root-Hour, Degree per Hour, Accuracy and Stability, Environmental Sensitivities.

AF02-199 TITLE: Improved UHF Antenna

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: The U.S. Air Force is seeking new ideas and technology for an effort to support the growing communications performance requirements for the reception/transmission of UHF radio signals with conformally mounted antennas mounted within the airframe of a modern evolving aircraft.

DESCRIPTION: This effort is directed toward the development of an UHF antenna for both receive and transmit functions,such as; voice, and satellite data communications. The antenna must operate in the band from 225 to 400MHz with a peak gain of better than -3dB conformally mounted on an evolving modern aircraft. Issues to be addressed are one or more of the following: (1) Communications abilities at ranges up to several hundred miles; (2) Gain of the antenna across the entire frequency band; (3) Performance of the antenna when integrated into the aircraft; (4) Low reflectivity out of band. In the past cavity backed spiral and slot antennas typically have been used for these functions but these approaches do not provide enough horizon gain to meet the range requirements of modern air vehicles.

PHASE I: Provide a report and possible supporting data to demonstrate the proposed approach describing the UHF antenna. Fabricate or prototype any portion of the antenna that would increase confidence in a Phase II effort.

PHASE II: Fabricate and demonstrate a protype in a test bed environment that adequately simulates the antenna mounted on and/or within the aircraft.

PHASE III DUAL USE APPLICATIONS: The proposed antenna has potential use on commercial aircraft or ground vehicles such as automobiles or buses primarily for improved aesthetic reasons. The primary use would be for the U.S. Air Force, Navy, and Army vehicles which require increased performance at high speeds and low refletivity out of the operating band.

REFERENCES:

KEYWORDS: UHF Antenna, UHF Communications, UHF Satellite Communications, 225 to 400 MHz, Conformal Antennas

AF02-200 TITLE: Continuous Track and ID Fusion (CTIF)

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: To continuously detect, track, and identify time-critical targets by fusing track and ID information in context of a robust, distributed tracking model, and database architecture.

DESCRIPTION: Achieving this capability in all-weather conditions and at standoff ranges cannot be accomplished reliably without fusion of sensor data from multiple sources using distributed robust tracking processies and database architectures. Current fusion approaches combine information at the decision level, which needlessly discards a tremendous amount of rich object/feature-level sensor information that could be otherwise fused for improved target detection, tracking and identification. Innovative detection, cueing, fusion algorithms, models, and architectures are needed for accumulating target identification evidence based on object-level target features from multiple sensors dispersed in time and space particularly when track and ID information is either fragmented or distributed. The result shall be cumulative, continuous combat identification of highly mobile surface targets through all phases of their movement history. An underlying objective of this continuous detection, tracking and ID effort is to develop novel concepts and techniques for sensing, processing, and accruing evidence from both distributed sensors, tracks, and databases using robust sensing, processing, tracking, ID, and database models to associate detection, track, and identification data on targets of interest originating from different collections. A key part of the research is to tie the solution to the sensor capabilities. This ensure that the solution is a complete one and fully exploits the sensing and processing capabilities within the context of the fusion solution.

PHASE I: Develop and implement optimal or near-optimal track detection, generation and estimation algorithms of surface moving targets that appropriately deals with target, sensor, and environment modeling uncertainties. Develop concepts and techniques for associating detections, track fragments, and identification information originating from different Intelligence, Surveillance and Reconnaissance (ISR) assets resident in multiple databases. Model and demonstrate these sensor-level continuous tracking and ID techniques via engineering analysis and simulation. The Air Force will help to identify and provide scenarios, descriptions, analytical models, and software tools that can be used to conduct the research. One goal of Phase I is to demonstrate the performance of the technique/s on simulated Ground Moving Target Indication (GMTI), High Range Resolution (HRR), and/or other sensor data.

PHASE II: The major goal of Phase II is the demonstration of the method on Air Force real data collections of Ground Moving Target Indication (GMTI), HRR, and/or other sensors. Efforts are likely to include further developments to meet operational requirements.

PHASE III DUAL USE APPLICATIONS: Known civilian application areas include commercial aviation, Intelligent Vehicle Highway Systems (IVHS), drug enforcement, and transportation systems.

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KEYWORDS: Cognitive Reasoning, Data Association (spatial and temporal) Algorithms, Data Fusion, Tracking and Identification, Tracking Model, Target Identification, Targeting, Feature-Level Fusion.

AF02-201 TITLE: High-Efficiency Amplifiers with Discretely Variable Output Power

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a power amplifier for phased-array antennas to provide high efficiency at discrete power levels

DESCRIPTION: Electronic phased array antenna systems often require a power amplifier at each element or subarray. To form an agile beam while maintaining control over the radiated power, it may be necessary to vary the power delivered by each amplifier. Typically, amplifiers are optimized for high efficiency at a particular power level. When operating at other power levels, efficiency suffers, causing excessive use of costly prime power. The goal of this project is to develop innovative designs for microwave/millimeter-wave amplifiers to achieve efficient operation at a small number of discrete power levels.

PHASE I: Phase I activity will include the following key tasks: 1) Investigate the trade space of high efficiency transistor amplifiers with discretely variable output power. The output power should vary discretely between 0 and a few watts in a small number (two to eight) of steps. The investigation should address linear amplifiers with at least 10 percent bandwidth and 30 percent power-added efficiency at discrete frequencies between 1GHz and 100GHz. Consider parameters such as transistor type, semiconductor material, circuit topology, amplifier class, bias levels, and related properties. 2) Develop conceptual designs of high-efficiency amplifiers with discretely variable output power at one or more frequencies in the 1 GHz to 100 GHz range. The designs should achieve small size, lightweight, and low cost, and use an easily implemented method of controlling output power. Switching frequency between states should be at tens of KHz or greater. 3) Identify critical elements of the design for detailed development during Phase II.

PHASE II: Perform detailed design of the amplifiers developed in Phase I. Develop and test functional prototype amplifiers to demonstrate feasibility of critical elements of the design

PHASE III DUAL USE APPLICATIONS: Power amplifier efficiency is a critical factor in achieving long battery life in DoD and commercial mobile communications systems. The high-efficiency amplifiers with variable output power could be adaptively adjusted to maintain communications links while minimizing battery power consumption.

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KEYWORDS: Power amplifier, Power-added efficiency, Satellite communications, Transistor amplifiers, Monolithic microwave integrated circuit (MMIC), Phased array antenna

AF02-202 TITLE: Low Mass, Low Power, Digital Beamforming (DBF) Subarray for Satellite Applications

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Design a digital beamforming receive-only subarray antenna, with very low mass and very low power consumption, for satellite communication array antennas.

DESCRIPTION: Space-based digital communication systems that utilize a phased array antenna as either the main radiating aperture, or as a feed to a large reflector, can benefit from the high degree of pattern control and multiple simultaneous beams afforded by digital beamforming (DBF). In space-based systems, power and mass are at a premium, however, present day DBF channel hardware and DBF array designs do not meet satellite requirements. A/D

converters with sufficient resolution typically consume about 5W, and signal processors consume significantly more. In addition, conventional microwave radiating elements and feed lines have high mass densities and exhibit unsatisfactorily high RF loss. The goal of this project is to develop one or more receive-only DBF subarray architectures that comprise a unit cell in a modular DBF array architecture suited for satellite communications. Appropriate subarray design approaches shall feature the exclusive use of ultra-low mass materials, very low power consumption high-efficiency electronics, and RF aperture design approaches that exhibit very low RF loss. As a further constraint, appropriate subarrays must be designed as a modular component of a DBF array architecture, and be shown to exhibit sufficient G/T performance in that array environment, in order to prove the usefulness of the design for high speed satellite data communication. The subarray shall be designed to operate in the receive-only mode, and be capable of wide scanning in both azimuth and elevation planes, in an appropriate microwave communications band. With the exception of power supplies and signal generators, the subarray design shall contain and physically support all microwave and digital electronic hardware required for live testing.

PHASE I: The Phase I activity shall include the following tasks: 1) Investigate the use of very low mass flexible membrane materials such as Kapton or Liquid Crystal Polymer (LCP), used in combination with low mass rigid materials such as hex-cell, composites, or other materials, as a substrate for the subarray back-plane. 2) Investigate the performance and availability of commercial-off-the-shelf (COTS) electronics that have both low mass and low power consumption. 3) Develop circuit designs and electronic modes of operation that require very low power consumption and exhibit very low RF loss. 4) Develop advanced digital signal processing approaches and hardware implementations that consume very little power, yet provide full DBF functionality on receive, including channel equalization and adaptive weighting. 5) Design a subarray using results from the tasks described above. The subarray shall include all A/D, digital buffering circuitry, and microwave receiver components necessary to use the subarray in live tests that shall include measurement of the far field subarray pattern on an antenna test range.

PHASE II: Develop an operational prototype of the DBF subarray designed in Phase I. Experimentally demonstrate the operation of the subarray in the receive-only mode, and demonstrate channel equalization and the application of digital weights. Strong emphasis should be placed on measuring and quantifying the microwave and digital performance of the subarray, including dynamic range, signal-to-noise ratio, resolution, as well as measure the power consumption and RF loss of the subarray, and its mass.

PHASE III DUAL USE APPLICATIONS: A digital beamforming subarray having very low mass, and power consumption is an extremely useful component for DBF phased array antennas and DBF array feeds to lens and reflector antennas, for both military and commercial use. Space-based communication/surveillance/reconnaissance systems would benefit greatly from the development of this technology. Military applications include satellite communications systems at S-band and Extremely High Frequency bands. Commercial applications that would benefit from this technology include satellite-based global communications systems.

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KEYWORDS: Digital Beamforming, Low mass, Low power consumption, Phased Array Antenna, Subarray, Space-based Digital Communications

AF02-204 TITLE: Simulator Technologies for Rapid Prototyping of Advanced Receiver/Processor

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop/evolve simulator technologies for rapid prototyping of advanced radio frequency (RF) receiver/processor capabilities.

DESCRIPTION: Current research methodologies for evolving advanced RF receiver/processor capabilities are time consuming and require extensive/costly open-air range testing. Open-air ranges cannot generate the dense RF signal environments that would be experienced in actual real-world situations such as military combat scenarios. Open-air range productivity is low due to the fact that there are so many uncontrolled variables and the inability to make changes during the actual flight test. Receiver/processor research facilities do not have the real-time simulation capabilities to evolve advanced RF receivers/processors in the laboratory. Currently available laboratory RF emission simulators cannot provide the required fidelity and real-time signal environment generation capability. These laboratory simulators are costly to build because they achieve high fidelity through specialized RF synthesizers/modulators/amplifiers/attenuators and specialized digital control electronics that utilize expensive, precision-matched components. The current simulator architectures force the use of these expensive, precision-matched components. Increasing the laboratory simulator's fidelity through higher fidelity components is cost prohibitive and involves performance tradeoffs that actually limit the simulator's capability. As an example, inserting additional amplifiers in the signal generation chain to make up for precision component losses, raises the noise floor, limiting dynamic range and preventing the generation of realistic emissions. Current laboratory simulators cannot be effectively linked/operated together because they do not utilize the DoD High Level Architecture (HLA) concepts/requirements being sponsored by the Defense Modeling and Simulation Office (DMSO). This inability to effectively link simulators detrimentally limits the realism of the generated emitter environments. Research is being sought to create affordable dual-use simulator technology advancements that enable higher fidelity through innovative architectures and/or component technologies. This Small Business Innovation Research addresses simulator technology needs for the DoD HLA concepts/requirements being sponsored by the DMSO under the DMSO M&S Master Plan.

PHASE I: The Phase I effort will conduct the research required to define dual-use simulator component technologies and/or advanced simulator architectures that enable the affordable rapid prototyping of advanced RF receiver/processor capabilities in the laboratory. The research should envolve innovative solutions that do not require detrimental performance tradeoffs. The Phase I research will identify the implementation concepts and establish concept feasibility. The Phase I effort will define the Phase II approach for developing/demonstrating the improvements. Phase I risk reduction experiments will be conducted to demonstrate the feasibility of the Phase II approach.

PHASE II: The Phase II effort will implement and demonstrate the performance/benefits of the selected simulator component technologies and/or advanced simulator architectures.

PHASE III DUAL USE APPLICATIONS: The simulator component technologies/advanced simulator architectures can be implemented in government laboratories and test ranges for the development and evaluation of advanced RF receiver/processor capabilities.Simulator component and advanced architecture technologies are dual use technologies that have extensive commercial applications for markets such as the telecommunications industry. These technologies can be utilized to improve the laboratory capabilities enabling telecommunications equipment to be developed faster and more cheaply. These technologies reduce development costs and accelerate product movement to the market place through rapid prototyping in a laboratory development environment that incorporates realistic real-world effects.

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KEYWORDS: Simulator, Radio Frequency (RF)Simulator, Architecture

AF02-205 TITLE: Efficient Luneberg Lens for Multi-frequency SATCOM Antenna

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Investigate materials and fabrication techniques for wideband Luneberg lenses.

DESCRIPTION: A Luneberg lens is a sphere of low-loss dielectric material the index of refraction or relative dielectric constant varying along any radius. In the ideal lens this variation is continuous; however, this variation is often approximated by concentric spherical shells. When a hemispherical lens is placed on a ground plane reflections at

the ground result in an effective doubling of the aperture making a lens antenna ideal for aircraft installation. Luneberg lenses are inherently wideband and are a prime candidate for multi-frequency aircraft SATCOM antennas. Good performance has been achieved at 20 GHz; however, difficulty has been encountered in achieving maximum gain performance at 44 GHz. Close examination of shells indicates that fabrication difficulties result in non uniformities in the dielectric constant within a shell. Other fabrication difficulties such as air gaps between the shells decrease lens performance. In transmit systems the 165 deg F melting point of fabrication material can limit the RF power.

PHASE I: Investigate fabrication techniques and material which will result in a wideband lens with maximum gain efficiency and uniformity at 20 GHz, 30 GHz and 44 GHz. An 8" diameter hemisphere lens with a uniform gain of 40 dB at 44 GHz is the target goal. Explore fabrication techniques for lenses with continuously varying dielectric constant, multiple concentric shells, or other architectures and compare cost and performance results . Investigate the effects RF heating and the use of material with melting points above 165 F. Develop a design of a wideband lens to be fabricated in Phase II

PHASE II: Use the design selected in Phase I to fabricate at least 6 lenses. At 20, 30, and 44 GHz measure the gain and the uniformity of the gain over the hemisphere. Measure the radiation pattern, directivity and input VSWR. Final report should document performance capabilities, fabrication repeatability and temperature heating effects due to RF source power and maximum input power limitations.

PHASE III DUAL USE APPLICATIONS: DoD applications for Luneberg lenses include antennas for large aircraft in the AF Advanced Wideband Terminal (AWT) procurement. Commercial applications include use with emerging Ku and Ka band commercial satellite communications systems.

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KEYWORDS: Antenna, Luneberg Lens, Aircraft Antennas

AF02-206 TITLE: High Performance Atomic Clocks for Space

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Improve the performance of spaceborne atomic clocks for GPS.

DESCRIPTION: Interest in atomic clocks has grown in recent years, with developments in physics package design and supporting electronics. Lasers are being introduced for state selection and preparation that permit more efficient interrogation of atomic populations leading to improved discriminator signal-to-noise. Alternative modes of interrogation are being considered for new physics package designs. Microwave signal generation is benefiting from the new gallium arsenide technology and digital electronics is being used to provide more comprehensive management of clock operation. These innovations allow alternative and new opportunities for clock technology to achieve higher levels of performance. At the same time, GPS requirements continue to demand the very best clock technology that can be flown in space. Timing accuracy of better than a nanosecond per day demands an Allan deviation of less than 1E-12 per root tau, with a flicker floor below 5E-15 and negligible drift. This program will address new clock designs to support these performance goals.

PHASE I: Select a clock technology and perform an analysis to identify the critical parameters that establish its performance. Develop computer simulation of selected clock together with integration of improved technology. Through simulation, measure improvement to critical parameters. Fabricate /integrate the necessary breadboard components to improve precision. Demonstrate the viability of the technology and measure the improvement to critical parameters. Results should show promising performance and progress towards meeting the overall objectives of the program.

PHASE II: Build a prototype clock based upon Phase I results. Utilize prototype unit to demonstrate performance goals mutually agreed upon between the Air force and Contractor. SBIR contractor should endeavor to establish a partnership with an organization that can provide commercial resources to sustain product development and ensure a path to flight production and space qualification.

PHASE III DUAL USE APPLICATIONS: Atomic clocks are widely used in communication networks and avionics where timing requirements are critical. The development of space clocks for GPS extends capabilities in clock design and manufacturing, and provides new technology for these commercial applications.

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KEYWORDS: GPS, Atomic clock, Laser, Microwave signal, Atomic Clock Physics Package, Commercial resources

AF02-208 TITLE: Global Positioning System/Inertial Measurement Unit Ultra-Tightly Coupled Integrity Monitoring

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a global positioning system (GPS) integrity monitoring method utilizing Ultra-tight GPS coupling with an inertial measurement unit (IMU).

DESCRIPTION: GPS applications involving safety-of-flight operations (e.g., precision and nonprecision instrument landings) require integrity monitoring. Integrity monitoring can involve either onboard resources such as receiver autonomous integrity monitoring (RAIM) or offboard resources such as wide-area or local-area augmentation. Since measurements to only four GPS satellites are required for a GPS navigation fix, and there are normally many more in simultaneous view, most RAIM approaches traditionally rely on algorithms that use redundant satellite measurements. That is, unless there is consistency within allowable tolerances between the measurements to all satellites, there may be a problem with one or more measurements and the user is alerted to the possible error. With six or more satellites in view, it is normally possible to isolate the bad satellite. Experimental GPS landing systems have used a combination of inertial and radar altimeter measurements to implement the RAIM function. Several researchers have recently been investigating novel GPS-inertial integration techniques (deep-integration or ultra-tight coupling) that may yield markedly improved performance in the presence of signal interference. These techniques may be incompatible with conventional RAIM algorithms, but conversely may allow the implementation of even more effective integrity monitoring techniques. The purpose of this project is to develop, formulate, implement, and characterize the most effective RAIM techniques that exploit these new GPS-inertial integration architectures to obtain more robustness and greater reliability under all practical types of GPS and IMU failure modes.

PHASE I: In Phase I, develop computer simulation of the proposed solution. The simulation shall include the necessary levels of fidelity to test the contractor's approach with realistic degraded GPS and IMU performance parameters. Provide a simulation demonstration together with documented results and a detailed description of the finalized approach. A proposed Phase II outline shall be included in the final report.

PHASE II: Develop (Air Force/Contractor) mutually agreed test plans and procedures. The test program shall simulate various failure modes of GPS and the IMU, including soft failures. Perform tests (per plans) utilizing the finalized Phase I approach incorporating a real GPS receiver that is ultra-tightly coupled with an IMU. The test plan, procedures, and test data/results shall be included in the Phase II final report.

PHASE III DUAL USE APPLICATIONS: This technology will be applicable in the military Joint Precision Approach and Landing System (JPALS) as well as being applicable to civil airlines that use GPS for landing.

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KEYWORDS:

AF02-209 TITLE: Innovative Sensors and Algorithms for Detection and Identification of time critical targets

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop and evaluate innovative sensor and algorithm concepts for the detection and identification of advanced time critical targets.

DESCRIPTION: Combat missions must now be accomplished in the face of significant challenges such as: 1) enemy air defenders using enhanced surface-to-air missile defenses employing new engagement tactics such as frequent threat emitter shutdowns and shoot-and-scoot tactics; 2) targets under trees; and 3) moving targets. Innovative sensors and algorithms are required to improve detection range and identification of these time-critical targets. Enhanced detection range and positive hostile ID may be obtained through the use of systems onboard the targeting platform and/or from off board sources.

PHASE I: The development and evaluation of innovative sensor and algorithm concepts for detection and identification of advanced time-critical targets requires an understanding of what features unique to time-critical targets are present, and what sensor and algorithm processing capabilities are needed to reliably exploit them. Consequently, the Phase I effort will consist of a two-part feasibility study. The first will be to determine the existence and characteristics of candidate target features. Existng ground moving target identificatiion (GMTI) and synthetic aperture radar (SAR) target databases, assembled under recent DARPA research programs, could be used to support this initial feasibility study. The focus will be to assess the characteristics of time-critical target features that can be reliably exploited using advanced sensor concepts such as SAR/GMTI fusion, wideband space-time adaptive processing (STAP), and high range resolution (HRR.) The second part of the feasibility study would be to do an initial hypothesis test using existing target detection, cueing, and identification algorithms for continuous detection and ID of stationary and moving time-critical targets to assess the feasibility of fusing these features . This will be achieved by exploiting complementary components of GMTI, HRR, SAR, and Moving Target Imaging (MTIm) radar modes, sensor-level data mining, and clutter cancellation algorithms. This fusion of modes, data, and algorithms will be needed to rapidly align, correlate, and fuse sensor multimode data into an integrated, detect-and-ID capability in order to continuously pursue a ground target whether stopped or moving. The end result of this two part feasibility study will be to assess the presence and behavior of uniquely exploitable target signatures. As part of the feasibility study, key radar parameters and performance tradespace will also be identified for utilization in the prototype demonstration phase II.

PHASE II: This effort will be a prototype demonstration. Using the findings from the Phase I feasibility study, a prototype advanced sensing concept for time critical targets will be demonstrated. This will involve implementing and improving the fidelity of existing sensor detection and ID designs using target features identified in Phase I feasibility study. A key part of the prototyping demonstration is the integration of key radar sensor parameters such as pulse repetition frequency (PRF), bandwidth, dwell, transmitter power, squint geometry, platform speed, etc with the

algorithm behavior. This will ensure that the demonstration will accurately illustrate the interdependence between algorithm and sensor design for optimum detection, tracking, and ID as a function of the time critical target.

PHASE III DUAL USE APPLICATIONS: Known application areas include commercial aviation, drug enforcement, and transportation system analysis.

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KEYWORDS: SAR, GMTI, HRR, Sensor Modes, Time Critical Targets, Detection, Identification

AF02-211 TITLE: 3-D Reconstruction for Missile Recognition

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Establish approaches for robust, efficient automatic target recognition (ATR) and registration systems for missiles.

DESCRIPTION: Recent advanced in model-based target recognition techniques have greatly improved the capabilities for targets in the open (i.e. unobscured). While missiles are generally unobscured, their speed and size impose significant problems for the standard approaches. Thus, innovative ATR and registration approaches are requested for high-resolution sensor systems that roughly track a missile.Ballistic missile defense can include preventing a launch through successful theater interdiction, but more generally denotes disabling a ballistic missile in flight. The first step to defense is surveillance. Sensors are the eyes and ears for surveillance and the associated systems must provide the brain for interpreting the data. Obvious sensor (wavelength) choices include infrared and visible, but should not be considered as the only option. Applications include target detection, classification, tracking, and kill determination.Two important additional technical goals are to discriminate decoys and to improve trajectory estimates. Thus these goals necessitate a coherent framework for integrating multiple looks at potential targets and a trade-off between speed and accuracy. The natural framework is the 3-D geometry of the missile. The 3-D geometry of a missile can be determined by tracking it over an extended time period. In simple cases where the missile trajectory is known, tomographic reconstruction would be sufficient. However, in the general case where the trajectory with respect to the sensor is not known, a more general solution is required to reconstruct the 3-D object from the data. An added benefit of a more general approach is ability to simultaneously handle both platform and target motion (the more they move, the better the reconstruction). Ultimately, a general approach will easily lead into many military and commercial applications of ATR and registration.

PHASE I: Demonstrate a prototype approach for automatic missile recognition and registration. Clearly address the extended operating conditions, testing, and evaluation methodology for demonstrating the feasibility of the prototype approach. Suggest a modified approach based on evaluation of the prototype.

PHASE II: Implement modified approach suggested in Phase I. Evaluate results achieved on several nominal cases. Demonstrate robustness to obscuration, decoys, and chaff. Develop plans for database, index, and algorithm creation and updates. Deliver the algorithms for additional assessment and possible transition into user applications.

PHASE III DUAL USE APPLICATIONS: An efficient and robust system for acquiring and tracking small targets among other similar targets has a clear application to air traffic control and space monitoring. The technology developed will also have application to plume tracking for pollution and numerous other commercial, medical, and military applications requiring ATR algorithms.

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KEYWORDS: Automatic Target Recognition (ATR), Detection, Tracking, Reconstruction, Recognition, Identification.

AF02-212 TITLE: Dual-Use Visualization Tools For Aircraft System/Subsystem Performance Assessments

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop dual-use, real-time visualization technology/tools that reduce the cost/time for performance analyses/assessments.

DESCRIPTION: Modeling and simulation are being utilized extensively to predict/analyze the performance at both the system and subsystem levels for both military and commercial aircraft. The analysis of the simulation data requires considerable time and manpower/cost to translate the results into meaningful information/presentation formats that can be used for rapid system/subsystem design/performance assessments. Approaches leading to the creation of innovative, user friendly, dual-use visualization technologies/tools that automatically translate simulation results into high fidelity formats where the analyst can readily visualize the predicted performance are sought. The goal of this research is to evolve affordable dual-use visualization technologies/tools that increase the productivity of performance analyses/assessments and reduce analysis/assessment costs. This research should address the visualization needs of constructive (digital models), virtual (man-in-the-loop) and hardware-in-the-loop simulation. The dual-use visualization technology base established by this research will enable significant reductions in the time/cost for both commercial and military aircraft system/subsystem performance assessments. This SBIR visualization research addresses visualization technology/tool needs for the DoD High Level Architecture (HLA) concepts/requirements being sponsored by the Defense Modeling and Simulation Office (DSMO)under the DMSO M&S Master Plan.

PHASE I: The Phase I effort will conduct the research required to define affordable dual-use visualization concepts/technologies/tools for aircraft system/subsystem performance analyses/assessments. The key objective of this research is to create innovative dual-use visualization concepts/technologies/tools that increase the productivity of aircraft system/subsystem performance analyses/assessments and reduce analysis/assessment costs. The Phase I research will identify the critical technology challenges and define the Phase II approach for developing/demonstrating the required visualization concepts/technologies/tools. Phase I risk reduction experiments will be conducted to demonstrate the feasibility of the proposed Phase II approach.

PHASE II: The Phase II effort will implement and demonstrate the critical visualization concepts/technologies/tools.

PHASE III DUAL USE APPLICATIONS: Visualization concepts/technologies that increase the productivity of aircraft system/subsystem performance analyses/assessments and reduce analysis/assessment costs are dual-use technologies that have extensive commercial applications for markets such as commercial aircraft, automobile, and video game entertainment industries. These concepts/technologies/tools automate the translation of simulation results into visualization formats that enable the aircraft/automotive system design engineer/analyst to rapidly review/assess the information, which will allow the design teams to rapidly modify their designs to balance cost/performance trade-offs. These same concepts/technologies/tools can be utilized by the video game entertainment industry to enhance the visualization and interaction of video games. These same concepts/technologies/tools can be implemented in government laboratories and test ranges for rapid assessment of aircraft system/subsystem performance analyses/assessments.

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KEYWORDS: Visualization, Simulation, Assessment

AF02-213 TITLE: Material and Component Development for Millimeter(MM)-Wave Imaging Systems

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a material, processing, or integration technology to advance the state-of-the-art in mm-wave components for 140-GHz imaging receivers.

DESCRIPTION: Millimeterwaves (MM-Wave) can effectively penetrate fog, dust, and clouds during bad weather situations. The mm-wave signals can be sensed in a passive mode, much like in a visible imaging system that uses collection optics and imaging arrays. Therefore, mm-wave can be used to enhance an operator's vision in critical situations. The further development of mm-wave imaging systems will rely on improvements in materials, processing, and active components that can operate above frequencies of 140-GHz. Indium gallium arsenide and antimonide-based devices are good candidates for operation above the 140-GHz (mm-wave) range. These materials have the added advantage that they are readily integrable with mm-wave antenna elements. Integration of these structures on a common substrate would reduce the necessity for coaxial interconnects, thereby advancing system performance through enhanced efficiency and smaller size.This program seeks innovative approaches to improve the performance and reduce the cost of components used in mm-wave imaging systems. Innovative mm-wave circuit design and imaging system architectures are needed that reduce component count by increasing the level of integration. Novel materials growth and processing techniques are sought that will improve yield and device performance. For example growth of high indium content compounds on large diameter wafers would greatly reduce component cost. Processes of interest are transfer integration techniques that result in greatly improved device performance and allow the fabrication of semiconductor devices with low cost printed circuit antennas.

PHASE I: Demonstrate feasibility of new material technology or processing technique. Emphasis will be given to improving yield, device performance, or level of integration for components needed for mm-wave imaging systems. Performance and cost improvements in relation to mm-wave imaging systems will be documented.

PHASE II: Further develop the material, processing, or device technology investigated in Phase I. Fabricate prototype mm-wave components to demonstrate the feasibility of a 140-GHz imaging system based on the technology developed during Phase II. Demonstrate and characterize the operation of the mm-wave components.

PHASE III DUAL USE APPLICATIONS: The Air Force deploys an ever-increasing number of optical communication networks, both terrestrially and on airborne and space-borne platforms that use mm-wave components. Weight and other requirements increasingly dictate higher frequencies and more compact system designs for microwave and millimeter subsystems. Nondefense markets also exist in the areas of telecommunication, data networks, cable TV, ground links for wireless networks, and automotive radar.

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KEYWORDS: 140-GHz Imaging Sensor, EVS, Imaging Array, Indium Phosphide, MM-Wave

AF02-214 TITLE: 140 GHz Imaging Technology

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Innovative passive and active imaging systems for the 140-GHz atmospheric window.

DESCRIPTION: The need exists to develop an array of components in the 140-GHz frequency range for imaging. Advances in the III-V materials and devices, particularly in the indium phosphide-based material system, enable manufacturable, low-cost electronics for signal generation, control, and detection at frequencies through 140-GHz. With a wavelength of 2.1 millimeters, imaging at 140 GHz provides higher resolution and smaller components compared to imaging at lower frequencies. Arrays of transmitters or receivers, or both, could be made on a single monolithic millimeterwave integrated circuit. At 140 GHz, imaging systems can operate day and night in adverse atmospheric conditions. These features promise applications in landing guidance systems, navigation, targeting, weapons detection, and battle damage assessment by providing imagery through all weather conditions and in the day or night.

PHASE I: Activities in this phase shall include: 1) Develop a system concept for an active and/or passive 140-GHz imaging system. 2) Demonstrate the feasibility of components for receivers and transmitters for the imaging system. 3) Develop a plan for partitioning and integrating components in an imaging array.

PHASE II: Activities in this phase shall include: 1) Demonstrate integration of components for an imaging system according to the plan developed in Phase I. 2) Develop a system architecture for a complete sensor, including target/scene environmental issues.

PHASE III DUAL USE APPLICATIONS: Potential applications are in military transport, commercial airlines, and airfreight as an enhanced vision system (EVS) sensor.

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KEYWORDS: 140-GHz Imaging Sensor, Enhanced Vision Systems, Millimeter-Wave Components, Indium Phosphide-Based Materials

AF02-215 TITLE: Real Time Sensor Image Fusion

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Design, evaluate and build a real-time image sensor fusion system capable of penetrating night and weather that aircraft pilots can use during instrument approach/departure procedures.

DESCRIPTION: New image fusion approaches based on neural networks are being developed which can provide a real-time sensor image fusion capability suitable for use with an enhanced vision system (EVS) for instrument approach and departure procedures. The image fusion/EVS architecture will provide a heads-up display (HUD) with a substantially enhanced image for the pilot while flying in adverse weather and at night. The architecture can utilize sensors ranging from different types of infrared (IR) (~300 THz) to W-band (84 to 94 GHz) to Ka-band (26-40 GHz), each having its unique resolution, weather penetration, and night vision capabilities. Images from two or more of these sensors shall be processed and fused for display as an EVS video image for a HUD, which may include aircraft information. The goal is for the assimilated image to provide more information than any one individual sensor while suppressing sensor artifacts such as noise, blooming, and dead pixels. The image fusion/EVS system will provide the pilot and copilot with an optimized visual image as the aircraft transitions from initial approach to the missed approach point. The color weather radar (35 GHz) has better weather-penetrating capabilities than an IR sensor, but it has lower resolution. The best application would be ground mapping or terrain-following and could be used for executing initial approaches or low altitude navigation. The W-band frequencies (84 - 94 GHz) provide sharper resolution than the 35 GHz. This resolution could enhance airfield and runway identification, obstacle detection, and runway incursions while executing the final approach. Since IR has the best resolution and night vision capabilities, this imagery is best used for taxi and departure procedures and final approach at night. This image fusion/EVS system will combine the best features of these sensors to improve pilot performance while flying at night or in Instrument Metrological Conditions (IMC).

PHASE I: Develop and evaluate one or more designs to process and fuse the images provided by two or more of the following sensors: 35 GHz radar, 84 - 94 GHz millimeter wave (radar or passive system); and IR. Contrast the feasibility and accuracy of two or more approaches, and provide a preliminary design for correlating the fused image with terrain and vertical obstruction databases. Provide a preliminary approach to certification of the image fusion for flight safety system and hazardous misleading information mitigation.

PHASE II: Perform preliminary demonstrations of initial image fusion applications using realistic sensor data. Determine what levels of performance are required for the image fusion/EVS system to be used during instrument approach/departure procedures. Develop the capability to correlate the fused sensor images with terrain and vertical obstruction databases. Select the best approach to demonstrate a prototype image fusion system, including preliminary tests at night, in reduced visibility and in IMC. Develop a initial design for implementing the EVS with a HUD in the cockpit. Initiate an approach to image fusion certification or authorization for use.

PHASE III DUAL USE APPLICATIONS: This image fusion system could be used in a variety of military and commercial applications requiring improved vision for navigation, surviellance, threat warning and ATR in adverse weather and night vision conditions. This information can be presented through projection displays, HUD and Heads Down Displays, and can also act as an integrity monitor for the primary navigation and landing system. More conventional EVS engineering developments based on single sensors are being independently pursued by commercial airlines and airfreight carriers. The US Air Force, HQ AMC, and HQ AFSOC are exploring the potential application of this technology under the JPALS Program. NASA Langley Research Center is also pursuing a Synthetic Vision Systems (SVS) program for use in the high-speed civil transport aircraft and in general aviation safety.

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KEYWORDS: Image fusion, sensors, surveillance, threat warning, vision systems, Enhanced Vision System, instrument approach and departure procedures, EVS, HUD.

AF02-218 TITLE: Network Multiple frame Data Association

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop and evaluate multi-hypothesis multi-frame tracking techniques for decentralized applications where multiple linked platforms exchange sensor-derived information to produce an improved operational picture. Warfighter Impact: This effort will contribute to the development of a fusion algorithm that will help AWACS meet its key performance parameter of multi-source integration (MSI).

DESCRIPTION: Multiple platform tracking, herein called network-centric tracking, can significantly improve tracking performance over single platform tracking due to geometric diversity and sensor variety. In addition, the fusion of information from multiple platforms yields a more global surveillance picture for battlefield management. For example, OSD's Multi-Platform Tracking Exploitation (MPTE) demonstrated enhanced continuity of track using operational platforms connected with operational networks. In the network-centric tracking environment, the inter-platform issues of decentralized data association (sometimes called correlation) and estimation are central and inseparable parts of the same problem. While decentralized tracking has focused on decentralized fusion and estimation, the central problem of decentralized data association using multiple frame processing has received little attention. For platform-centric tracking (i.e., single platform with single or multiple sensors) or centralized tracking in which all measurements are sent to a central processing location with tracks being transmitted back to the different platforms, multiple frame data association methods such as multiple hypothesis tracking (MHT) or multiple frame assignments (MFA) offer the ability to handle difficult tracking issues such as closely spaced objects, false signals and clutter, radar multi-path, residual sensor registration biases, and counter-measures. Multiple frame data association methods also offer improved performance in accuracy of the target tracks, discriminants, and covariance consistency, which in turn reduces track switches, track breaks, and missed targets. For network-centric tracking, one architecture that achieves outstanding tracking accuracy is the aforementioned centralized architecture; however, this architecture is generally unacceptable for multiple platform tracking due to communication loading and the single-point failure problem. Thus, the primary objective of the program is to develop and demonstrate a decentralized, network-centric, multiple-frame association algorithm that approaches the performance of a near-optimal centralized architecture across a network of platforms while managing communication loading and achieving a consistent air picture. In addition to these objectives, one must also deal with a number of problems such as (1) the types of information (e.g., measurements, tracks, tracklets) sent across the network; (2) sensor location and registration errors (sometimes called gridlock); (3) design for the use of information pedigree; (4) out-of-order, latent, and missing data due to both sensor and communication problems; (5) network topology; and, (6) use of attribute data. This effort differs greatly from the majority of work sponsored previously in that it seeks to integrate concepts from a number of approaches into an overarching system. The question of centralized versus decentralized tracking is an ongoing debate. While we know that the right answer is to use centralized tracking, the reality is that not all communication link bandwidths support this and for significant platforms the bandwidth will likely never exist. To leverage the benefits of multiple-platform tracking we are seeing in large surveillance platforms into and with smaller platforms we need multi-frame trackers that can process both reports and tracklets.

PHASE I: Investigate, develop, and establish the feasibility of innovative algorithms that perform network-centric multiple frame data association. Identify issues related to network-centric multiple frame data association methods. Investigate the effects of the issues identified relative to tracking performance and propose solutions to the network-centric multiple frame data association problem that mitigates these effects.

PHASE II: Develop a prototype distributed architecture, algorithms, and software for robust network-centric multiple frame data association and demonstrate its effectiveness in achieving superior tracking performance while managing communication loading and achieving a consistent or single integrated air picture. Other activities may include testing and evaluating the effectiveness of such architecture.

PHASE III DUAL USE APPLICATIONS: Network-centric multiple frame data association that achieves a consistent air picture while managing communication loading can yield significant tracking performance and information fusion enhancements for multiple surveillance platforms operating in a dynamic, uncertain, and adversarial environment. In the commercial market, the development of real-time adaptive team decision making, distributed control architectures, and sensory processing are equally applicable to the field of robotics [7] as well as to both economic and corporate modeling [6] where one allocates assets to optimize some global objective over both global and decentralized (local) constraints. Law enforcement applications exist which are very similar to military applications. For example, border surveillance by the Drug Enforcement Agency and the Immigration and Naturalization Service.

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KEYWORDS: multiple hypothesis tracking, network-centric tracking, distributed data association, consistent single integrated air picture

AF02-219 TITLE: Environmentally Driven Signal Processing Technology for Overland Height Finding

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop innovative algorithms and processing schemes to provide critical overland, low target height-finding capability to airborne surveillance sensors. Warfighter Impact: Accurately detecting, tracking and prosecuting low, slow flying airborne vehicles is a key operational requirement that must be, but currently is not, met by conventional ISR sensors due in part to conventional processing methods. Future ISR sensor systems will likely be implemented on unconventional air vehicle designs utilizing conformal apertures and distributed sparse arrays. Such implementations offer many advantages but may also negatively impact tracking accuracy, particularly the ability to accurately locate and track the elevation component of a targets motion. This underscores the requirement for innovative methods of obtaining accurate positional estimates of difficult targets. This SBIR topic will provide technology to aid the warfighter in precisely determining the altitude of low, slow flying objects with much greater accuracy using advanced signal processing technology for improved kill chain effectiveness and target prosecution.

DESCRIPTION: Significant progress has been made in demonstrating the potential benefits of knowledge-aided (KA) signal and data processing. The incorporation of auxiliary sources of knowledge such as DTED, DFAD, LULC and other sensor information to (1) adaptively adjust the processing algorithms and their parameters to more closely match the environment, (2) adaptively and dynamically manage the sensor-level resources to change modes, waveforms, dwell time, and illumination schedules to enhance difficult target detection in severe interference environments and non-ideal geometries where grazing angles, ranges, platform altitudes and terrain cover/topology combine to degrade detection performance and tracking (to include height-finding) and (3) management of the ISR constellation (whether it be spaceborne, airborne or a hybrid) to address flight/orbit management, constellation and platform tasking, and inter-platform synchronization to improve detection and tracking, including height estimation. Additionally, high fidelity modeling has progressed to the point where predictive knowledge of the environment can be used to substantially improve the performance of electromagnetic sensors, and further extract critical position data, which ordinarily would not be available using conventional processing methods. This topic focuses on the application of advanced KA signal processing techniques to enhance detectability of slow, low flying targets and provide precise estimates of target altitude by virtue of the external interactions of the target with the electromagnetic environment.

PHASE I: Investigate advanced KA signal processing algorithms for altitude estimation of low flying targets overland based upon predictive knowledge of the environment.

PHASE II: Develop algorithms and perform sensitivity analysis quantifying dependence of errors on the accuracy of environmental knowledge for a significant number of geo-specific environments. Provide hardware and software specification to implement a real-time system.

PHASE III DUAL USE APPLICATIONS: The innovative technology developed will have a direct benefit to significant sensor problem areas, including height finding, electronic support measures (ESM) tracking, sensor evaluation, hot clutter mitigation and automatic target recognition (ATR)/Foliage Penetration systems. This will enable future tactical implementations involving precision handover from surveillance systems to fire control assets such as forward pass, over the horizon (OTH) targeting and defensive ESM.It is anticipated that cartographic data derived directly from geo-specific remotely sensed imagery would be used to drive the advanced signal processing algorithms. With continued advances in computing hardware and software, remote sensing and its kindred information

technologies, such as Geographic Information Systems (GIS), could be directly inserted into tactical systems as a result of this applied research.

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KEYWORDS: Height Finding, Altitude Estimation, 3D, Precision Location Estimation, Knowledge-Assisted Processing,Knowledge Base Processing, Artificial Intelligence, Expert Systems, Signal Processing, Algorithms.

AF02-221 TITLE: Improved Pose Estimation for Tracking and Identification Systems

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: The objective of this effort is to develop an improved tracking and identification system by using a very accurate pose (the orientation of the target relative to the tracking platform) estimates to reduce the "search space" of the identification algorithm. Here the search space is defined to be the set of "training" signals (e.g. from a high range resolution radar) that the algorithm has to compare the observed radar signals to determine the target type.

DESCRIPTION: Ground moving target indicator (GMTI) radar is known to track position and velocity of ground moving targets. Pose can be derived from these kinematics estimates of position and velocity (e.g., pose equals the angle between position and velocity). This pose estimate is sometimes used to reduce the search space of an identification algorithm. Due to the resolution of some radar systems, the GMTI tracker estimated pose sometimes exhibits very large errors causing large search algorithms and sometimes-faulty identification of potential targets. This SBIR will contribute to the development of improved tracker pose estimates for better tracking and identification of targets. The goal of this SBIR task is to investigate ways to improve coupled tracker and identification systems. Some possibilities might include using road and terrain data or somehow tracking micro-motions (i.e., tracking roll, pitch, and yaw) of the target.

PHASE I: The first task that the offeror will perform is to determine and predict the performance (degradation or nondegradation) of both the tracker and the identification systems due to poor knowledge of pose. Since JSTARS is one major platform where coupled tracking and identification is being considered, analysis will focus on such systems. If there exist problems, the offeror will suggest new/novel techniques and investigate them until good performance is obtained. Further, the offeror will calculate the sensitivity of changes in various parameters to probability of miss-association

PHASE II: The major goal of Phase II is the demonstration of the method on Air Force GMTI simulations and/or on real data from GMTI collections. Efforts likely include further developments to meet operational requirements

PHASE III DUAL USE APPLICATIONS: Known civilian application areas include commercial aviation, Intelligent Vehicle Highway Systems (IVHS), drug enforcement, and transportation systems. Military applications include surveillance of the battle space with an improved and integrated picture of the battlespace among platforms.

REFERENCES:

J. Layne and D. Simon, " A Multiple Model Estimator for a Tightly Coupled HRR Automatic Target Recognition and MTI Tracking System," SPIE Conference on Algorithms for Synthetic Aperture Radar Imagery VI, Orlando, Florida, April 1999.

KEYWORDS: Tracking, Target, Identification, Pose, JSTARS, and Feature Aided Tracking (FAT)

AF02-222 TITLE: Fusion-Aided Continuous ID for Targeting (FACIT)

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Only a limited amount of target classification has been done using the feature-level fusion of advanced radar modes. This Fusion-Aided Continuous ID for Targeting (FACIT) topic will be used to develop algorithms for the identification and targeting of time-critical targets through all stages of the move-stop-move cycle.

DESCRIPTION: The DARPA Moving Target Exploitation (MTE) program developed advanced tracking technologies while demonstrating proof-of-concept for limited target classification using advanced radar modes. The objective of FACIT is to extend the baseline MTE target classification technologies by developing and demonstrating advanced MTE target classification capabilities. This includes innovative feature-level fusion of advanced sensor modes and their algorithms for the ID of ground moving targets at extended standoff ranges in all-weather and all day, whether moving or stationary. This capability will support the reconnaissance, surveillance, and strike-support missions of air and space-based platforms; specifically, ground order of battle (GOB) reconnaissance and surveillance of ground moving targets, and the targeting of time-critical targets (TCT) through all phases of a move-stop-move cycle.

PHASE I: To achieve this advanced MTE capability, comprehensive target detection, cueing, and identification algorithms need to be developed for continuously identifying stationary and moving targets by exploiting complementary components of ground moving target indication (GMTI), high range resolution (HRR), synthetic aperture radar (SAR), and Moving Target Imaging (MTIm) radar modes, sensor-level data mining, and algorithms. This fusion of modes, data and algorithms will be needed to rapidly align, correlate and fuse sensor multimode data into an integrated tracking and automatic target recognition (ATR) capability in order to continuously prosecute a ground target whether stopped or moving. Major advancements will come from work developing advanced object-level sensor exploitation as well as tracker-assisted classification technologies to include but not necessarily restricted to, feature-aided tracking and range-doppler ATR. Multiplatform GMTI continuous ID will be demonstrated using appropriate object-level resource management and target information accural.

PHASE II: Further refine the continuous target ID architecture and software algorithms to implement the approach developed in Phase I. The Phase II effort will implement and demonstrate the fusion aided continuous ID/targeting capability defined in Phase I. A commercialization plan will be developed.

PHASE III DUAL USE APPLICATIONS: This technology could be used in a broad range of military and civilian applications where continuous tracking and identification of objects in motion is needed. Known civilian application areas include commercial aviation, drug enforcement, mass transportation system, industrial security, and Intelligent Vehicle Highway Systems (IVHS).FACIT technology is particularly suited to long range all weather surveillance applications. In the drug war, there is a need to monitor US coastal waters for suspicious water traffic possibly indicative of incoming shipments of illegal drugs by fast speed boats. Current practice is to then vector airborne surveillance followed by the interdiction by boat. Given the need for wide area surveillance and accurate tagging of complex surface moving traffic patterns for cost effective and efficient vectoring of drug enforcement personnel, the FACIT technology could be tested by installing a wideband XBAND radar on GulfStream jet and then install and adapt the FACIT software in an onboard computer to cue and differentiate drug carrying speedboats by their unique doppler behavior and radar hull signature.

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2. Yaakov Bar-Shalom, "Mutlitarget-Multisensor Tracking: Applications and Advances," Artech House, 1992.

KEYWORDS: Target Identification, Targeting, Feature-level Fusion, MTE, Sensor Exploitation

AF02-223 TITLE: Coupled Tracker and Identification Algorithms

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop an advanced avionics system, which can perform joint target tracking and target identification. Target tracking and target identification (ID) are typically treated as independent systems. This SBIR will investigate ways to exploit couplings in these systems to improve performance.

DESCRIPTION: In recent years researchers have attempted to couple tracking and ID systems by investigating methods of using radar signal features to aid the tracker association problem. Such approaches are often referred to as feature-aided tracking (FAT). However, little attention has been given to the problem of combining information at the tracker kinematics estimation level to improve the tracker estimates. Other researchers [1-3] have shown that there exists a coupling (namely, the pose angles) between these systems. Other couplings might exist. By tightly integrating these systems, significant improvement in the overall performance might be obtained.

PHASE I: The first task that the offeror will perform is to determine all possible couplings between track and identification systems. The second step is to find ways to exploit these coupling in joint tracking and ID systems. Since

JSTARS is one major platform where coupled tracking and identification is being considered analysis will focus on such systems. The offeror will suggest new/novel techniques and investigate them until good performance is obtained.

PHASE II: The major goal of Phase II is a demonstration of the methods on Air Force ground moving target indication (GMTI) and high range resolution radar (HRR) simulations and/or on real data from GMTI and HRR collections. Efforts likely include further developments to meet operational requirements

PHASE III DUAL USE APPLICATIONS: Known civilian application areas include commercial aviation, Intelligent Vehicle Highway Systems (IVHS) drug enforcement, and transportation systems. Military applications include surveillance of the battle space with an improved and integrated picture of the battle space among platforms.

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KEYWORDS: Tracker, Identification, Joint Systems, Pose

AF02-224 TITLE: Multiple Database Evidence Accrual Techniques

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop concepts and techniques for accruing evidence to associate detections, track fragments, and reports resident in multiple databases.

DESCRIPTION: Situations occur in Intelligence, Surveillance and Reconnaissance (ISR) where large data gaps may exist between reports from individual assets. These assets have different sensing capabilities and the information is reported to various databases. Delays in information handling and processing may cause older data from various assets to lag availability of newer data in the databases. For example, identification may not become available until a target has left its' original location and been tracked by other assets. Because of data gaps and data latencies, traditional techniques for real time data fusion and tracking may be inadequate. The objective of this effort is to develop novel concepts and techniques for accruing evidence to associate detection, track and identification information on targets originating from different assets in ISR databases in order to form a common tactical picture. Part of this effort will include identification of limiting parameters for these techniques. Parameters of interest may include, but are not limited to target densities, length of data gaps, data latencies, location errors, and type of data. This effort will include development a model for the above evidence accrual problem and determination of the sensitivity of correct associations to these parameters. Specific sensors of interest onboard these assets could include; foliage-penetrating (FOPEN) radars, Ground Moving Target Indicator (GMTI) radar, Synthetic Aperture Radar (SAR), high-range resolution (HRR) radar, electro-optic/infrared (EO/IR) sensors, communication intelligence (COMINT), and signal intelligence (SIGINT). Each of these sensors provides different information. FOPEN can provide detection of fixed concealed targets, but not direct identification. GMTI can provide track histories on moving targets, but track fragmentations are likely to occur due to obscurations or the target stopping. If the target is in the open, identification and location data can be obtained from other assets, such as SAR, HRR radars and EO/IR sensors. COMINT, and SIGINT can provide good identification information, but poor location data. A subset of these types of sensor reports should be considered for Phase I demonstration purposes.

PHASE I: Develop concepts and techniques for associating detections, track fragments, and identification information originating from various ISR assets resident in multiple databases. Model and demonstrate these concepts and techniques via engineering analysis and simulation. Identify limitations and sensitivity of these techniques. The Government will help to identify and provide scenarios, descriptions, analytical models, and software tools that can be used to conduct the research.

PHASE II: The major goal of Phase II is prototype development and demonstration of the concepts developed in Phase I through more realistic simulations. This phase of the effort is likely to include further refinement of the algorithms

and techniques to better address issues identified in Phase I and further developments to meet operational requirements such as scenario enrichment. Maturity assessment will be performed to identify additional work required for transition.

PHASE III DUAL USE APPLICATIONS: Commercial applications could include Air traffic Control and collision avoidance. Medical applications could use patient histories to detect precursor conditions and reduce diagnosis costs. Another commercial application could be intelligent associative search engines. Military applications would include ISR and targeting applications.

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KEYWORDS: Cognitive reasoning, Data association (spatial and temporal) algorithms, Data fusion, Tracking and Identification

AF02-227 TITLE: Ultra-Wide Band Perimeter Surveillance Sensor

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop an automated and unmanned Ultra-Wide Band (UWB) Perimeter Surveillance Sensor, designed to operate alone or in concert with other sensors.

DESCRIPTION: With decreasing manpower resources available to the U.S. military, the need to exploit advances in technology for the protection of military bases, critical assets, and other facilities is essential. It is anticipated that a UWB Perimeter Detection Sensor, with detection ranges of up to 5 kilometers for individuals and 10 kilometers for vehicles from a central location, may be cost-effectively achieved. The number of sensors to be deployed is site specific and not identified here. A minimum number of sensors are desirable for a reduced infrastructure and maintenance footprint.A single UWB sensor should provide all weather, all terrain, wide area (360 degrees) capability to detect and track intrusions in open areas. It should detect during both day and night in atmospheres containing rain, fog, smoke, haze, dust, and clear air. Detection ranges for this sensor should be: (a) Walking/Running, 500 meters required, 5000 meters desired; (b) Crawling, 250 meters required, 750 meters desired; and (c) Vehicles, 1000 meters required, 10,000 meters desired. The UWB sensor should localize target range within 10 meters and target azimuth within 10 degrees. It should provide the capability for area mapping. False alarm rates should be less than three per 24 hours and less than two nuisance alarms per hour. The UWB sensor can be commercial or battery powered with an objective of charging the battery via solar power. Production unit costs should not exceed $50,000 per copy.A compact and lightweight sensor is requested. As such, COTS technology, no matter how desirable, may not be appropriate for this UWB perimeter surveillance sensor. Some designs may incorporate UWB radio frequency (RF) sensors operating (radiating) simultaneously throughout an area. As such, self-jamming must be mitigated via signal processing for ease of deployment. Primary reporting should be made to a central security location. As an additional objective, it would be desirable to report detection and tracks to responding forces equipped with hand-held viewing devices much like commercially available Palm Pilots. Communications from the UWB perimeter surveillance sensor over ranges of 3 to 10 km is envisioned. As a baseline, a short-pulse, active UWB radar operating in the VHF/UHF frequency bands should be considered for foliage penetration. Fopen is essential to the success of this effort. This allows for minimal propagation attenuation, while high range resolution permits coherent scene change detection optimized for moving troop/vehicle detection. The R&D technical risks associated with this topic arises out of concern over the selection of suitable technologies for waveform generation, timing and control. Here the tradeoff is between short pulse and spread spectrum waveforms. Compatibility with antenna and receiver technology is of lower risk. Suitable signal and data processing technology for detection, track and reporting exist in the open literature. A wide range of UWB radar technologies, systems and conops will be considered under this effort, and are not limited to the illustrative examples and discussion provided herein, so long as detection ranges in foliage or in open areas are met.

PHASE I: Develop a baseline design and an integrated approach to a UWB Perimeter Surveillance Sensor that will accomplish the tasks discussed above. Identify high-risk technology and long lead time components. Perform preliminary simulations that indicate how well the proposed concept addresses the stated tasks. Demonstrate adaptive algorithms to be used in the UWB Perimeter Surveillance Sensor on the simulation data generated as a part of this Phase I task. Design an experiment for demonstration of the proposed sensor at the Griffiss Business and Technology Park, NY, or a suitable alternative.

PHASE II: Breadboard prototype and demonstrate the UWB Perimeter Surveillance Sensor designed under Phase I at the Griffiss Business and Technology Park.

PHASE III DUAL USE APPLICATIONS: Dual use applications in the commercial arena include UWB Perimeter Surveillance of construction sites, storage sites, and mining operations. Additionally, the need to protect intruders from harm at hazardous sites is also of high interest in industry today. Civilian applications include UWB Perimeter Surveillance of airports, borders, international shipping ports, truck depots, and prisons.

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KEYWORDS: Ultra-Wide Band, Radar, Monostatic, Multistatic, Adaptive

AF02-228 TITLE: Move-Stop-Move Signature-Aided Tracking

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Associate reports from multiple Radar sensor modes to improve tracking of ground targets that transition between moves and stops. Warfighter Impact: By improving continuity of track, this effort will improve target prosecution performance by weapon delivery platforms such as Joint Strike Fighter as well as battlefield awareness by surveillance systems such as JSTARS and Global Hawk.

DESCRIPTION: This topic considers the registration of reports from dissimilar sensor modes to maintain continuous track of objects. In many data fusion systems, continuity of track is required so that information can be accrued about each object. Accrual of information allows decisions about what each object is and what is it doing. Having the ability to continuously track an object that repeatedly moves and stops will improve Air Force capabilities in critical areas such as maintenance of battlefield awareness and tracking of time-critical targets. Revolutionary approaches will be developed to improve tracking performance in move-stop-move scenarios by allowing association of moving target radar signatures with stopped target radar signatures. Association of moving target signatures to stationary target signatures is not well understood so any research accomplished can provide cutting edge developments. As used here, radar signatures can range from specific features extracted from the radar return to results of advanced radar modes such as synthetic aperture radar (SAR) imagery, high-range resolution (HRR) 1-D profiles, and moving target imagery (MTIm). On-the-fly signatures will be developed that essentially fingerprint the target and allow tracking the target through move-stop-move transitions. For example, a Ground Moving Target Indicator (GMTI) radar mode can track a moving target, but loses detections when the target drops below its minimum detectable velocity and stops. At this point, the radar can use its SAR mode to determine the signature and location of the motionless target. Similarly, advanced GMTI radar modes such as HRR and MTIm also produce moving target signature information. The concept developed here is that stopped target signatures can be compared to moving target signatures to determine which moving targets actually stopped and where. When the target begins to move again, the new moving target signatures can be compared to both stopped target signatures and previously-collected moving signatures. Thus, continuous track of the target through the full move-stop-move sequence is obtained. This likely requires extracting signatures in new ways from the video phase history (VPH) received from the stopped and moving targets. The robustness of the overall association process with respect to signature variations due to pose, depression, and squint angle along with moving target signature effects will likely be an issue. The DARPA's Moving Target Feature Phenomenology for Track Maintenance (MTFP) program will provide an excellent basis for the effort. The MTFP will provide motion compensated VPH of a number of targets while they are both moving and stopped. The MTFP program will also provide studies of moving target features and methods for extracting them but does not consider stationary target features. DARPA's Moving and Stationary Target Acquisition and Recognition program may provide insight into suitable features. New algorithms for performing association within the multi-target tracker will be proposed and studied. The algorithms should allow the tracker to associate sensor reports from dissimilar sensor modes.

PHASE I: The feasibility of associating stopped target radar signatures with moving target radar signatures shall be studied. Radar signature processing methods for both moving and stopped targets shall be defined and implemented as necessary to support the study. Tradeoff studies and analyses will be used to identify and understand significant issues.

For example, robustness with respect to target pose and radar squint angle is expected to be issues. The study should indicate how well the association process should work. Multiple-target tracking algorithms that allow continuous tracking of the target shall be identified. This includes developing new concepts for how to modify the trackers report association process.

PHASE II: Develop a prototype system that demonstrates improved tracking of targets that repeated move and stop. This includes developing a signature-aided, move-stop-move, dwell-based tracker and establishing the technologies impact. The offeror may incorporate their algorithms into Air Force simulators resident at AFRL/SNA that can incorporate real data from radar collections. Other tasks could include maturity assessment and risk reduction as time permits. Other potential issues that could be investigated include the benefit of adaptive waveform design, and effective methods for mutual scheduling of radar identification modes from multiple platforms. Efforts should help determine tasks for a potential Phase III effort.

PHASE III DUAL USE APPLICATIONS: Many applications require the ability to track objects through move-stop-move transitions that could benefit with the decision logic and concepts developed. The research is directly applicable to border surveillance for the Drug Enforcement Agency and the Immigration and Naturalization Service. Decision algorithms developed are applicable to intelligent vehicle highway systems (IVHS) and law enforcement applications that use GMTI along with EO/IR sensors. Robot applications exist which require tracking objects through move-stop-move transitions using sensors that have modes similar to radars. Military applications include battlefield surveillance and sensor-to-shooter.

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KEYWORDS: Multiple Target Tracking, High-Resolution Radar, GMTI Radar, Report Association, SAR

AF02-229 TITLE: Analog to Digital Coverters

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop a low power, high-resolution analog to digital converter on an ASIC chip.

DESCRIPTION: As signals and interference powers increase, navigation, communications, radar and computer systems must be able to operate effectively with higher resolution analog to digital converters and their corresponding increases in dynamic range. A need exists for the development and demonstration of a low power, low cost and small size Analog to Digital Converter (ADC) prototype chip which can be integrated in a handheld receiver with the following specifications:- 16-bit resolution- 50 MHz bandwidth (min)- 100 MSPS- 100 mw - Signal to Noise Ratio: 90 dB (min)- Spurious Free Dynamic Range: 100 dB - Two's complement output format - CMOS digital output levels

PHASE I: 1) Investigate technologies applicable to the design of a low power, low cost, small size ADC meeting the requirements above. 2) Develop detailed models of candidate ADC designs. 3) Perform analyses/cost and trade studies. 4) Select final design based upon performance/cost/power criteria. 5) Based on selected design, provide a limited proof-of- concept demonstration to mutually (Air Force/contractor agreed specifications. The basic focus would be the integration by simulation with a Global Positioning System (GPS) receiver in the loop.

PHASE II: 1) Produce final detailed design of the ADC. 2) Produce a proof of concept prototype ADC capable of demonstrating all key performance features. 3) Conduct tests/demonstrations to mutually (Air Force/contractor) agreed specifications to measure/verify the ADC performance. 4) Provide final ADC cost/power analysis.

PHASE III DUAL USE APPLICATIONS: Development of the ADC has both DOD and Commercial applications in the future for navigation, communications, radar and computers.

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KEYWORDS:

AF02-232 TITLE: Accurate Computational Electromagnetics (CEM) Techniques for High Frequency Applications

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop Accurate and Efficient Computational Electromagnetics (CEM) Techniques for Radar Signature Prediction of Airborne Targets at Frequencies up to X-band.

DESCRIPTION: The Air Force increasingly relies on the advanced computational electromagnetics (CEM) tools for its low-observable weapon systems design and synthesis data generation for automatic target recognition, as budgets cannot support extensive design testing and flight data collection. While CEM tools have matured tremendously in the last decade, accurate radar cross section (RCS) prediction of a real airborne target at X-band, such as a fighter aircraft, remains a technical challenge. The challenge arises from the fact that, at X-band, target physical dimensions (60 ft length and 40ft. wingspan are typical) and surface area are very large compared to the wavelength (1.18" at 10 GHz.). Properly resolving the wave physics at X-band for such targets leads to prohibitively large computer memory and run time requirements for first principles CEM prediction methods. While the advent of high performance computing (HPC) and fast matrix solver technology in the 1990s has increased the problem size one can solve using first principles CEM techniques, such as the method of moments (MoM), it still has not overcome the order of magnitude increase in computational resources required for accurate X-band prediction. Thus, the less-accurate CEM techniques based on the asymptotic methods, such as the physical theory of diffraction (PTD) and the Uniform Theory of Diffraction (UTD), are still methods of choice for X-band predictions. Attempts have been made to increase the accuracy of the asymptotic techniques by adding higher-order scattering effects, such as traveling waves and tip diffractions. But even for some simple classes of targets the accuracy of such attempts can fall far short of first principle computations. In this effort, the Air Force is seeking innovative CEM techniques that further increase the problem size one can solve with controllable accuracy and increased efficiency. Potential approaches could be, but are not limited to, hybridizing the asymptotic methods with the first principle methods and/or further exploring fast matrix techniques and algorithms that exploit HPC architectures.

PHASE I: Develop the framework for the innovative CEM technique and demonstrate its potential for accurate RCS prediction of an airborne target.

PHASE II: Develop a CEM code coupled with HPC technology to demonstrate the feasibility of the innovative technique. Validate the code using existing RCS benchmark data.

PHASE III DUAL USE APPLICATIONS: The resulting CEM code could be further developed or integrated into existing CEM codes (military or commercial) and used to more accurately predict: 1) terrain and urban center wave propagation and multi-path effects on wireless communication systems, 2) antenna-to-antenna coupling or isolation in ground, airborne and space-based communication systems, 3) antenna/platform integration effects on antenna performance for commercial aircraft, 4) the location and detection of buried objects and 5) biomedical diagnostic imaging.

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KEYWORDS: Computational Electromagnetics (CEM), Radar Cross Section (RCS), First Principle Technique, Asymptotic Technique, High Performance Computing, Fast Matrix Solver

AF02-233 TITLE: Integrated Electro-Optical and Radio-Frequency Aperture

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop architecture, components, and integration technologies to enable common apertures from radio to optical frequencies.

DESCRIPTION: Almost all Air Force missions require some form of sensing. The predominant methods of sensing employ transmission and reception of radio frequency (RF) or electro-optical (EO) wavelengths. Historically, these two sensing modalities have not been considered in common because of the 4 to 5 orders of magnitude difference in wavelengths. The RF systems have long made use of phased arrays of emitters and receivers as a means of implementation. Recent advances in EO technology have produced corresponding phased array concepts in the EO domain. These advances now make it possible to consider the integration of the RF and EO aperture into a common component. Such a common aperture will reduce space requirements on platforms that are already crowded, and will enable the use of the best sensing modality for the specific conditions and mission. This topic seeks to define the basic architecture of a common RF and EO aperture for both transmission and reception of electromagnetic energy. It will define the component technologies needed to implement the integrated aperture. Necessary components will be fabricated and tested, and a proof-of-concept aperture will be built and demonstrated.

PHASE I: The basic architecture for an integrated RF/EO aperture will be defined. Component technology requirements will be generated and simple feasibility experiments on the component level will be accomplished as appropriate. Modularity of the components will be stressed.

PHASE II: Design of the integrated aperture will be accomplished, components will be fabricated, tested, and integrated. A proof-of-concept RF/EO aperture will be demonstrated and its applicability to military missions will be defined.

PHASE III DUAL USE APPLICATIONS: A particular application will be identified that employs both RF and EO energies. An integrated aperture for this application will be designed, fabricated, and demonstrated. Any platform in which both RF and EO sensors are employed can benefit from this effort. Commercial aircraft and possibly automobiles of the future can employ modules developed under this topic.

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KEYWORDS: Electromagneic and Optical Apertures, Optical Phased Arrays, Multifunction Apertures.

AF02-234 TITLE: Truth Quest: Enabling Operational/Exercise Data

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: To investigate innovative processes for collecting and truthing realistic sensor data for automatic target recognition (ATR) development and test.

DESCRIPTION: A new system or toolset must be developed to process operational and exercise data for use in ATR development and testing. Although the requirement for ATR systems is driven by the growing volume and complexity of operational sensor data, ATR research and development is limited by a lack of realistic training and test data. This apparent contradiction results from a lack of truth for the realistic operational data. Truth, as defined by the ATR community, is the knowledge of where targets are in the collected imagery. Truth information is essential for determining ATR performance. Current methods of image truth rely on controlled collections, manual operation, and are time intensive. Controlled collections are typically performed to enable truthing, but they necessarily compromise realism. New technologies must be developed to define truth conditions for realistic data collected operationally or at training exercises. Research may fall into one of three categories: postcollection image-based truthing, precollection

instrumentation, or assessment methods when the truth is uncertain or otherwise degraded. Example approaches are provided to help define the research problem; they are not necessarily recommended.Postcollection technologies may leverage the fact that human analysts routinely exploit the data. Tools and procedures are needed that capture exploitation results, refine and augment those results, and create truth in the form used in ATR research. An example refinement method would be to fuse exploitation results across time or sensor modality to improve truth estimates for a particular image.Precollection instrumentation used at exercises could also be improved. As an example, equipment may be added to targets to record, time stamp, and direction-find sensor illumination. A system might then take sensor data and target illumination data to compute elements of image truth. An unmanned aerial vehicle (UAV) might repeatedly visit and image beacon equipped vehicles to provide articulation, configuration, background, and obscuration truth. An emitter might be placed on a target to mark itself in sensor data. One challenge is that the emitter must not overly corrupt the signature of interest.Finally, new technologies are needed for scoring procedures and metric uncertainty characterizations when the truth associated with this realistic data may not match the quality of conventional collections. An example scoring tool extension would be one that made detection-truth associations dependent on the truth location uncertainty.Truthing systems would ideally be fully automated and result in a data product with truth and characterized uncertainty, be low cost, be applicable to stationary and moving targets, and be unobtrusive to the exercise or operational collection. Sensed data products of interest include SAR (high and low frequencies), high range resolution (HRR) radar, spectral imagery, and ladar. Targets of interest include ground vehicles and natural and manmade confusers (buildings, roads, trees, etc.). Target states of interest as truth include position, velocity, pose, type, version, configuration, background, and environment. These lists are not exclusive.

PHASE I: Phase I would develop a system concept for post collection truthing,precollection instrumention or algorithm assessment and prove technical feasibility.

PHASE II: Phase II would build and demonstrate the truthing and/or scoring system.

PHASE III DUAL USE APPLICATIONS: Phase III would develop and apply a product or service based on the truthing system.

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KEYWORDS: Truth Data, Truthing, Image Truth, Ground Truth, Sensor Data, Sensor Data Exploitation, Automatic Target Recognition (ATR), Target Position, ATR Evaluation

AF02-235 TITLE: Opportunistic Sensor Resource Management for Extended Operating Conditions

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop and demonstrate algorithmic methods providing the capability to control distributed sensor networks in extended operating conditions.

DESCRIPTION: In general, distributed sensing systems today place unprecedented demands upon the software that controls them. Over the last two decades, diverse sensing applications such as video surveillance, automated manufacturing, intelligent traffic control, and military surveillance, have experienced similar growth and challenges. Advances in electronics, communication, and networking technologies have enabled larger arrays containing more sophisticated, durable, and programmable sensors. This has provided increased coverage and flexibility for sensor arrays, making it possible to deploy them in more complex environments. Sensor systems are increasingly required to face extended operating conditions in which objects may be obscured or hidden, sensor performance may be degraded due to environmental conditions, and there may be a large number of tasks compared to available resources. Further, in more stressful applications both the sensor and the objects of interest may be in motion. Under such conditions the control of distributed sensing systems becomes an extremely difficult combinatorial optimization problem. A large number of sensors must be assigned to specific sensing tasks, and subsequently moded, and pointed to provide maximum effectiveness in a given amount of time. This effort shall seek to advance the state-of-the-art in distributed sensing applications through the development and demonstration of foundational algorithmic methodologies for the control of sensor arrays operating under extended operating conditions. The methods developed should balance sensor

usage to supply adequate spatial coverage while focusing in to discriminate necessary information, and be opportunistic in that they hedge against future extended operating conditions by collecting data at favorable times (e.g., when objects are not hidden, when sensing is available, etc.) and using that data for inference when extended operating conditions are encountered. As this effort is concerned with the development of an extendable algorithmic methodology, proposers need not be experts in sensor or environmental modeling for any particular application -- course statistical models are favored. For example, a sensor's classification capability may be modeled by a confusion matrix relating discrimination capability against a few object classes, and subject to a few pertinent situational parameters (sensing geometry, environmental conditions, etc.).

PHASE I: Identify a focus problem generally representative of a military surveillance mission and define extended operating conditions. Develop algorithmic methods to solve the focus problem. Demonstrate the methods developed using a simulation and test. Analyze test results and determine technical feasibility of approach for more realistic military surveillance missions.

PHASE II: Improve focus problem (and simulation) developed in Phase I by incorporating more realistic sensor and environmental models. Develop, and demonstrate algorithmic methods developed under Phase I.

PHASE III DUAL USE APPLICATIONS: The development of robust distributed sensor control methods for extended operating conditions has applicability to video surveillance, intelligent traffic control, automated manufacturing, and a large variety of remote sensing applications including military intelligence, surveillance, reconnaissance, and strike missions. Algorithms devised may also have applicability for distributed control of complex switches in communications and power networks.

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KEYWORDS: Multi-sensor Resource Management, Sensor Management, Distributed Control, Distributed Sensing, Intelligence, Surveillance, and Reconnaissance (ISR) Missions

AF02-236 TITLE: Novel Concepts for Multi-Mission Radar

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: This effort addresses techniques for the simultaneous detection, track and geo-location of air and ground targets.

DESCRIPTION: The requirement for multidimensional situation awareness is increasing for both military and commercial sensors. Dominance in the military theater demands systems that can perform multiple functions such as airborne moving target indication (AMTI), ground moving target indication (GMTI), synthetic aperture radar (SAR), and ELINT, as well as have the capability to defeat CCD (using FOPEN, Ground Penetrating Radar, Special Observable Exploitation, etc.). Current solutions to solve this problem revolve around the incorporation of shared aperture techniques. Limitations in physical implementation of the shared apertures, prime power availability, and basic phenomenology associated with the multiple functions must be balanced against command situational awareness constraints. In developing this functionality, time, frequency, polarization, and mission priority conflicts need to be resolved while maximizing output of required information in these radar modes. The integration of these modes may be a matter of carefully scheduling each function in time, or allocating based upon prime power, or prioritized based upon mission directive, or if necessary, ways of implementing the modes simultaneously needs to be developed.

PHASE I: Given the goal of precision location of air and ground targets using a single radar sensor, this effort will identify, define and model the necessary radar technologies required to accomplish these functions either simultaneously or in a manner that appears simultaneous to the radar operator. Computer simulation will bound the problem providing performance envelops under various prime power, update rate and field of regard conditions. Measures of effectiveness will be developed and used to assess the techniques developed.

PHASE II: Reduction to Practice -The goal of this phase of the effort is the demonstration of long pole technologies resulting from the phase one effort. These technologies will be demonstrated through either hardware demonstration of selected techniques or computer analysis of data cubes representative of the stressing technologies being reduced to practice.

PHASE III DUAL USE APPLICATIONS: Not only will this work be instrumental in developing a DOD radar surveillance and tracking system, but would also be applicable to many commercial applications.- Airport surveillance of ground traffic to help avoid collisions with aircraft that are landing and taking off- Phenomenology exploitation for civil engineering applications- Navigation and geodetic research in marine applications- Remote sensing

REFERENCES:

KEYWORDS: Multi-mission Radar, Radar, Radar Scheduling, Airborne Moving Target Indication (AMTI), Ground Moving Target Indication (GMTI), Synthetic Aperture Radar (SAR), Foliage Penetration Radar (FOPEN), Intelligence, Surveillance and Reconnaissance (ISR), Concealed Target Detection, Knowledge Based Techniques, Multifunction Waveforms, Multi-Platform Techniques, Simultaneous Transmit and Receive.

AF02-237 TITLE: Innovative Phenomenology Characterization and Advanced Algorithms

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop collection methodologies and algorithms to accurately characterize the dielectric constant at VHF/UHF/HF radar frequencies.

DESCRIPTION: In order to develop multi-mission sensors with the capability to detect difficult targets in foliage and below the earth's surface in the presence iof ECM and RFI, the Air Force must develop a means to effectively characterize the phenomenology associated with foliage penetration at UHF/VHF wavelengths and various geologies at HF and then exploit this phenomenology via advanced processing for mitigating interference, reducing false alarms, and enhancing target detection. The Air Force must acquire the capability to accurately characterize and model these scattering environments over wide frequency ranges to be used by future foliage and ground penetrating radar systems. The research of characterizing the dielectric constant of a forested environment will include the design of techniques to measure the desired biomass charateristics over frequency ranges from 20 to 600 MHz. The data collection system shall implement the techniques to provide measurements that will have to be conducted through mature forest stands for a variety of tree types, during all seasons and through various geologies, reaching different penetration depths, and in different soil and moisture characteristics. The data will be used to develop and validate RF interation models needed for the assessment of future surveillance and communications system operating in dense foliage environments and various surveillance and geo-science applications requiring the characterization and detection if objects buried below thr earth's surface. In concert with the development of techniques to measure phenomenology, algorithms and modeling and simulation tools will be developed to exploit this phenomenology. False alarm control, interference mitigation, and adaptive algorithms will be developed.

PHASE I: (1) Develop conceptual design of measurement technique(s) for wideband characterization of the dielectric constant of forested environments and subsurface geologies. (2) Using these conceptual techniques, design a measurement system that will collect the required data. (3) Develop innovative signal processing approaches that exploit findings in foliage and ground penetration phenoimenology to better control false alarms, mitigate interference, and improve target detection.

PHASE II: (1) Develop proof of concept prototype data collection system based on the techniques and system design on work done in under Phase I. (2) Identify issues pertinent to the accurate data collection of dielectric constant characterization data from mature forest stands and subsurface geologies. (3) Refine the prototype for data collection and analysis of data. (4) Develop modeling and simulation approaches to generate multi-channel data for FOPEN and GPEN data analysis, aid in the analysis of collected data, and advanced algorithm development.

PHASE III DUAL USE APPLICATIONS: The commercial potential is excellent. The implementtion of a device that measures the dielectric constants of forested environments and subsurface geologies over wide bandwidths has never been done before. Biomass characterization like this will be of great interest to the communications community as they migrate to ultra-wideband in the future for a complete wireless environment for the transfer of telephone and data signals between clients and service providers. Geoscience applications requiring a means to characterize the earths subsurface structure and detect underground structures and geological features could have commercial and military significant. Algorithms that utilize this improved phenomenology understanding to reject interference and enhance

signal detection will be of key interest as spectrum crowding and increased channel utilization become limiting factors in markets such as the commercial wireless industry.

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KEYWORDS: phenomenology, foliage, foliage penetration radar, FOPEN radar, ground penetrating radar,subsurface target detection, signal processing, phenomenology exploitation

AF02-242 TITLE: Variable Speed Aerial Refueling Drogue

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop innovative technologies to provide aerial refueling from hose/reel systems at airspeeds ranging from 95 through 280 knots.

DESCRIPTION: Current air platform hose/reel refueling systems are only useful in a narrow airspeed range due to the nonlinear dynamic instabilities of the hose & drogue with airspeed. A novel system capable of controlling these instabilities such that we can refuel vehicles over a wide airspeed range will fill a void currently existing in the USAF tanker inventory. For example, USAF tankers are unable to use the same drogue to refuel both helicopters and fighters on the same sortie. This deficiency is exacerbated by the advent of tilt-rotor aircraft that fly in an intermediate airspeed regime non-optimum for existing drogues. Additionally, drogues currently in use have no overlap in airspeeds and there exists no aerial refueling capability for airspeeds of 130 through 180 knots, a favored range of the CV-22. The identification of innovative technologies and concepts are needed to overcome these limitations, and could be aided by the use of modeling and simulation. Such technologies are broad but could include, for example, adaptive structural concepts that actively modify the aerodynamic shape of the hose or drogue and possibly used in conjunction with a broad range of active flow control devices. The challenge will be to develop and integrate these emerging technologies into an operational, robust refueling system. If successful, the system may also serve as a prototype refueling system for Unmanned Air Vehicles (UAVs). UAVs will require precise active control of the drogue to successfully coordinate hookup without a pilot on-board.

PHASE I: Identify and define concepts to achieve refueling capability over desired airspeed range. Establish performance goals. Perform modeling and simulation analyses of defined concepts to determine technical feasibility. For each concept estimate the weight, system (refueling system & tanker) integration impact, and development costs.

PHASE II: Based on Phase I modeling, design and develop the most promising concept into a prototype. Perform hardware experiments of pressurized system to quantify/verify performance. Provide risk/feasibility analysis of integrating prototype to operational flight system, including safety concerns. Provide revised cost, weight, and system integration analysis from Phase I.

PHASE III DUAL USE APPLICATIONS: Technology developed under this effort will be directly applicable to aerial refueling systems worldwide, thus the technology could be licensed to U.S. and non-U.S. aircraft manufacturers, providing the contractor a much wider customer base. There are also plans to augment expensive space-based satellites (commercial and military) with cheaper, more assessable, high altitude, and very long endurance UAVs. These UAVs will require precise, periodic refueling to maintain their position. In addition, these technologies could be applied in other cases where precise aerial control of a pressurized hose could improve current performance. One could envision, for example, adapting this work using various nozzles and accounting for aircraft velocity, wind speed, and spray pattern to allow more precise aerial discharge of fluids for application to aerial fire fighting or crop dusting.

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KEYWORDS: Drogue, Refueling, Tanker, Helicopter, Tilt-rotor, Flow Control, Adaptive Structures

AF02-243 TITLE: Logistics and Maintenance System Model Development and Integration into Real-Time Mission Level Simulation Environment

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: To create a simulation architecture that models mission level air vehicle life-cycle logistics and maintenance support.

DESCRIPTION: Over the years the Air Force has had numerous logistics and maintenance computer programs developed for specific purposes that are difficult to integrate together and into the emerging mission environment. The Air Force has an interest in innovative and state-of-the-art approaches to manage and minimize air vehicle life-cycle logistics and maintenance support systems costs. The techniques sought should be capable of evaluating "Legacy Aircraft" (i.e., F-15, F-22, C-17...) support systems. Functionality should include the identification of accumulated labor maintenance and acquisition costs, from the flight line to the depot. The techniques should be compatible with real-time, full mission simulation tools to allow the Air Force to determine the most effective methods to identify and mitigate total ownership, supply, and acquisition costs; assess technology insertion and performance; reduce maintenance actions, and reduce operational and safety costs. The technology will allow the Air Force to develop techniques to enhance the readiness, responsiveness, and agility of combat support systems in a relevant mission level environment.

PHASE I: Evaluate and identify existing appropriate air vehicle logistics and maintenance support systems models, simulation environment, and developmental and assessment tools for integration into the appropriate mission environment. Total system capability should accommodate the development of an open system environment to allow the user to insert customized or commercial cost and logistics/maintenance support systems algorithms. The selected models and tools should address supply costs, acquisition costs, mission capable rates, mission effectiveness, cost algorithms, and evaluation metrics. Investigate the adequacy of existing maintenance databases and information systems to provide baseline maintenance cost information for the model. An approach for a proof-of-concept demonstration to be executed in Phase II should be formulated.

PHASE II: Incorporate the air vehicle logistics and maintenance support systems models, simulation environment, developmental and assessment tools, cost algorithms, and evaluation metrics into an automated simulation software architecture module. Perform an F-15 proof-of-concept demonstration using actual flight data and support hours and costs. Required demonstration data will be supplied by the F-15 SPO, ASC/FBA at no cost. Accomplish simulations and show results of introducing upgraded subsystem examples into the air vehicle. Examples should include both near-term, conventional improvements and longer range, new technology.

PHASE III DUAL USE APPLICATIONS: The technology developed under this effort has diverse military and commercial applications. Any military or commercial activity with large material inventories and distribution network could utilize this technology. Target areas include terrain, marine, and air shipping and cargo services facilities, logistics and maintenance consulting firms, city and state rapid transit authorities, major retailers, warehousing and order processing companies, and transportation simulation and modeling facilities.

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KEYWORDS: Cost Modeling, Logistics, Modeling and Simulation, Mission Effectiveness, Management Algorithms, Total Ownership Costs, Life-Cycle Costs, Air Vehicle Support, Labor Maintenance, Acquisition Costs

AF02-244 TITLE: Rapid Fatigue Life Projection for Thermal and Acoustic Loads

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: The objective of this research is to develop the relationships between the probability density function (PDF) and the power spectral density (PSD) of the nonlinear response of a structure. Given those expressions, more realistic fatigue life approximations are possible.

DESCRIPTION: Current frequency domain fatigue life estimation tools do not take into account geometric nonlinearities, nor the instabilities associated with thermal buckling. Ideally, the analytical expressions developed in this SBIR would be coupled with developing nonlinear structural analysis programs, to provide a comprehensive nonlinear response/fatigue life estimation tool. Technical challenges include establishing the relationship between the structural nonlinear strain-displacement response, PSD and the PDF. The purpose of this research is to develop analytical expressions for the unstable random vibration fatigue life of composite structures with simultaneous thermal and acoustic loads, using frequency domain methods. Improvements are needed for the estimation of the fatigue life due to the thermal acoustic loads on current and future short take-off and landing (STOL) and hypersonic vehicle structures, as well as developing commercial reusable space access vehicles. Traditionally thermal-acoustic fatigue problems were solved with Palmgren-Miner's rule together with a time domain method, i.e., a given stress time-history and corresponding cycle counting method. More recently, frequency domain methods have been developed that deal with the limitations of the narrow band solution procedure, and allow a fatigue life estimation to be accomplished without the need for an experimental time-history. Consideration should be given for developing expressions for PDFs of the 'rainflow ranges' in the fatigue model, specifically for a geometrically nonlinear system. The solution procedure should account for the multimodal frequency response instability of restrained plates under acoustic and thermal loading. Consideration should also be given to the critical temperature change that produces plate buckling, temperature gradients along the edge, and improvements in iterative procedures. Finally, the analytical techniques should include the use of high temperature composite materials such as ceramic matrix composites.

PHASE I: The Phase I product would be the newly developed dynamic fatigue models, or analytical expressions, relating the structural nonlinear response, PSD and PDF, for composite panels.

PHASE II: Demonstrate the validity of the new models by example and validate using an experimental, sponsor provided database.

PHASE III DUAL USE APPLICATIONS: Incorporate the new fatigue model into a comprehensive, commercial finite element analysis package. Dual use applications include STOL aircraft, military space plane, and commercial reusable launch vehicles.

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KEYWORDS: Dynamic Fatigue Model, Random Vibrations, Thermal Buckling, Composite Plates, Snap Through, Probability Density Functions, Acoustic Excitation, Spectral Moments, Rainflow Cycle Counting, Frequency Domain

AF02-245 TITLE: Crack-Growth Methodologies for Cold-Worked Fastener Holes in Aluminum and Titanium Alloys

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop a methodology for predicting crack growth from and around cold-worked fastener holes and determine the stress-intensity factor solutions for cracks at or near these holes.

DESCRIPTION: Cold working fastener holes in aluminum and titanium alloys is a widely used technique in the aerospace industry for improving the fatigue performance of structures. A compressive tangential stress introduced in the material during the cold working of the hole reduces the natural tendency of the material to crack at the holes under cyclic tensile loading. It is a lucrative technique for the aerospace industry in that it provides an increase in performance without any weight cost.The technique most commonly used to cold-work fastener holes is a process of pulling an oversize mandrel through the hole to be cold worked. A thin lubricated sleeve is inserted between the hole and the mandrel before cold working in order to limit material flow in the direction of mandrel movement. The process calls for an optimum radial expansion of the hole and then subsequent reaming. The process yields the plate material and creates a compressive residual stress around the hole. Research has shown that this cold expansion can greatly extend the life of the part in question and is currently widely used in both military and commercial aircraft.However, the introduction of a compressive stress will cause a residual tensile stress further away from the hole. It is possible that this tensile stress field away from the fastener hole may cause cracks to develop away from the fastener hole. The concern is that most inspection procedures focus on the fastener hole itself and if cracks are forced away from the hole they might be missed by current inspections. Analysis methods or solutions for this type of cracking are not available in the current literature and should be developed.

PHASE I: Investigate methods of crack growth that can occur away from a cold-worked fastener hole. This should include a literature search of previous work done in this area as well as those aircraft and hardware that have exhibited this problem. Develop preliminary analysis of the hole and surrounding area with stress intensity solutions and expected crack growth rates, as well as the rational cause of such off-hole cracks.

PHASE II: Develop methodology to predict crack growth rates from off-hole cracks and determine the stress-intensity factor solutions for cracks at or near the holes. Integrate methodology into crack growth module for life prediction. Confirm the methodology, verify module accuracy and publish the verified results.

PHASE III DUAL USE APPLICATIONS: Crack growth methodology for off-hole initiation is needed by the military and commercial aviation industries, as well as benefiting the automotive industry or any industrial area where cold working of holes is required. This will have application in a number of military and commercial environments including aircraft, navel vessels, and vehicles.

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KEYWORDS: Fatigue, Fracture Mechanics, Cold Working , Life Prediction Methodology,

AF02-246 TITLE: Lightning Protection of Revolving Aircraft Turrets

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop innovative lightning protection technology for revolving composite aircraft turrets in flammable leakage zones.

DESCRIPTION: Composite materials are being used extensively to lower the weight and improve the performance of modern aircraft, but composites cannot survive the large currents produced by a lightning strike. Current state-of-the-art lightning protection systems such as metal screens and coatings have proven successful in protecting nonrotary composite aircraft structure but are insufficient to transfer the high current from a revolving composite turret to an aircraft fuselage as in a Boeing 747 airborne laser weapon system. Since lightning commonly attaches to an aircraft at its extremities, composite nose-mounted turrets are extremely vulnerable. An innovative, lightweight approach to shield and conduct lightning energy away from a revolving composite turret needs to be developed. The approach must include a grounding path across the rotary interface between the turret and the fuselage that does not induce sparking or arcing even at high turret rotational rates. This requirement exists to protect a flammable leakage zone from being exposed to an ignition source. Also, the lightning protection system must not interfere with the optical quality of a glass lens contained within the turret.

PHASE I: Define the proposed lightning protection system concept and concept requirements, and predict the performance of the proposed design. Demonstrate basic system concepts in a laboratory environment.

PHASE II: Provide a prototype lightning protection system and laboratory demonstration to mutually agreed performance parameters. Demonstrate that the lightning protection system is capable of supporting flight demonstration at a government facility and qualifies for an airborne experiment. The prime consideration must be the deliverable of a lightweight lightning protection system with a clear demonstration to protect composite and optical glass turret structures while providing a nonarcing grounding path over the turret to fuselage interface.

PHASE III DUAL USE APPLICATIONS: Any airborne system, current or future will be susceptible to lightning strikes. Airborne system platforms, such as the 747, have commercial and DoD application. These systems, in order to reduce weight, and improve performance and range, have applied the use of composite materials. Specific potential military applications for the lightning protection system include nonstationary interfaces such as turrets on the airborne laser weapon system and tanks, rotary domes on AWACS, trailing wire antenna on the E-4B, tilt-rotor bodies, and composite rotor blades. Composite rotor blades, tilt-rotors, and other aircraft parts with nonstationary interfaces make up some potential commercial applications for the lightning protection system.

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KEYWORDS: Lightning Protection, Composite Structures, Turret, Dynamic Interface, Lightweight Grounding Path, Build-up of Static Charges, Optical Qualities

AF02-247 TITLE: Supportable Sandwich Control Surfaces

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop and demonstrate new and highly innovative sandwich structure control surface concepts that are highly producible, low cost, and are not susceptible to structural degradation due to moisture intrusion, impact damage, and damage growth.

DESCRIPTION: Structual design trade studies have traditionally shown that sandwich structures are the most weight efficient concept for stability-critical components such as control surfaces. Prior applications of sandwich structure on in-service vehicles has resulted in costly manufacturing and supportability problems. Manufacturing problems have been caused by core materials that are difficult to machine and difficult to bond, difficulties in panel joining, and difficulties with integration of hard points for concentrated load introductions. Supportability problems have resulted largely due to the integration of materials and concepts that are highly susceptible to impact damage and moisture

intrusion which leads to corrosion, mechanical degradation of the sandwich core, and delamination in core-to-facesheet bond. This program seeks innovative sandwich structure solutions that are producible, mitigate the historical shortfalls of sandwich, and provide high structural efficiency. Sandwich structures which feature integral core and skins, damage and moisture resistant materials, and net shape cores may be considered.

PHASE I: The Phase I program will involve identifying and assessing the payoff of a unique sandwich structural configuration that minimizes structural weight and cost and is highly producible and damage resistant. The feasibility of the concept shall be demonstrated experimentally.

PHASE II: The Phase II program will further develop and demonstrate the producibility and robustness of sandwich control surface concept on a generic component whose design is derived from an existing or emerging air vehicle weapon system. This will involve design, analysis and fabrication of a subcomponent. This subcomponent should be subjected to environmental conditioning, simulated flight loads, and impact. A repair concept should also be developed and demonstrated.

PHASE III DUAL USE APPLICATIONS: This program will offer significant improvements in reliability and maintainability by reducing acquisition cost, reducing inspection intervals, extending the damage tolerance threshold and improving design efficiency. The technology will be transitioned by directly involving systems representatives in the progress and results of the program. This will include keeping representatives from the Joint Strike Fighter (JSF), F-22, C-17 and Air Logistics Centers (ALC)cognizant of the program's successes so that direct application of opportunities can be exploited. Commercial aircraft applications are expected to be similar to military applications, and initial uses are likely to be in lightly-loaded structures. In general aviation, perhaps primary structure, where similar technology is in use today. Nonaerospace uses of similar structure can be visualized within transportation equipment.

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KEYWORDS: Sandwich Structure, Woven Fiber Preforms, Foam, Composites, Honeycomb, Truss Core, Weaving, Braiding, Net Shape

AF02-248 TITLE: Structurally Efficient Composite Concepts with Non-Traditional Load-Paths

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Demonstrate new and novel aircraft structural concepts to significantly increase mechanical performance of advanced composite structures while maintaining affordability.

DESCRIPTION: Composite structures for military air vehicles are generally constructed from a standard set of product forms such as prepreg tape and fabric, and molded structures reinforced with woven or braided preforms and fabrics. These materials and product forms are generally applied in structural configurations and arrangements that mimic traditional metallic structure. Traditional metallic structural arrangements rely on the isotropic properties of the metal. Composite materials provide the capability for a high degree of tailoring which should provide an opportunity for very high structural efficiencies. This project seeks to develop approaches for applying composite materials and product in new and novel arrangements specifically suited to composites with the goal of significantly increasing the strength, stiffness, durability, and damage tolerance of advanced composite structures. Specific areas of interest include concepts to increase: compression strength, buckling stability, concentrated load introduction, out-of-plane strength, impact resistance, load transfer through joints and intersections, and complex combined loading capability. Very novel approaches such as biomimicry, prestressing may be considered. The goal is to enable reduced structural weight and increase survivability over state-of-the-art structures technology while maintaining affordability. The concept must be broadly applicable to all classes of Air Force air vehicles. Specific emphasis will be placed on secondary structure application concepts. The overall objective of the program is to demonstrate the feasibility of new design concepts enabled by new emerging material and manufacturing processes, and to identify the benefits of applying these technologies.

PHASE I: The feasibility of the concept shall be demonstrated through fabrication and test of a representative structural component.

PHASE II: The Phase II program will further develop and demonstrate the concept on a generic component whose design is derived from an existing or emerging air vehicle weapon system. This will involve design, analysis and fabrication of a subcomponent. This subcomponent should be subjected to environmental conditioning, simulated flight loads, and impact damage.

PHASE III DUAL USE APPLICATIONS: This program will provide highly efficient structural concepts with broad applicability to a variety of Air Force systems. The technology will be transitioned by directly involving a major airframe partner and systems representatives in the progress and results of the program. This will include keeping representatives from the JSF, UCAV, Sensorcraft and the ALC communities cognizant of the programs successes so that direct application of opportunities can be exploited. Civil applications are somewhat difficult to determine at this time, as the specific concepts to be demonstrated are not yet selected. Application to civil aerospace and ground transportation can be visualized.

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KEYWORDS: Composites, Biomimicry, Weaving, Braiding, Pinning, Pultruded Rods, Truss, Cellular Structures, Prestressing

AF02-250 TITLE: Aerial Targets Modernization and Integration

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop innovative technologies, manufacturing and integrating concepts for aerial targets that increases their capabilities.

DESCRIPTION: The Air Armament Center is interested in innovative concepts to improve the performance and operability of aerial targets. The Aerial Target Program Office develops and acquires aerial targets and payloads for the Air Combat Command to test and evaluate radar and infrared aerial weapons. Aerial targets include both a full-scale aerial targets (i.e., QF-4) and subscale aerial targets (i.e., BQM-34 and MQM-107). Advanced concepts and innovations will be applied to several technologies and target-operable areas. Airborne technology areas under consideration, but not inclusive, include radio frequency (RF) missile-scoring techniques, flight endurance and engine performance, target control techniques, integrated and water-survivable payload concepts, carriage and threat replication payloads (electronic, chaff, infrared), aircraft manufacturing techniques, simulation and modeling, signal processing, and common aperture antennas.

PHASE I: This phase will determine the scientific or technological merit and feasibility of the concept, approach, and its cost effectiveness. Merit and feasibility must be clearly illustrated during this phase through a combination of analytical, empirical and experimental approaches. A technical evaluation of the concept or methodology; a demonstration of proof of principle; or a thorough description of the technical approach, cost effectiveness, alternative approaches, and risk factors may be appropriate in this phase. Examples of innovative ideas that are desired for subscale aerial targets include 75 minutes of mission time at 15,000 feet at military power and 45 minutes of mission time at 500 feet at military power; inexpensive turbojet engine subsystems that will improve performance between 250 KCAS to 1 Mach at 15,000 feet and 200 KCAS to 1.5 Mach at 15,000 feet; and inexpensive-commercial grade composite airframe structures that can sustain 10 Gs at 10,000 feet and sustained turn rates 20 deg/sec.

PHASE II: The effort in this phase is expected to produce a well-defined deliverable product or a process. Demonstration of the concept, process or idea is desired on a representative model, avionics suite, or a full-scale representation of the air vehicle. Any development of the software coding that is required to demonstrate the idea or process in the avionics, engine, and airframe shall have a written description of the intent of the subroutines. If the idea, process and concept has considerable technical payoff, affordable to demonstrate, and is flight survivable, a subscale aerial target may be provided to demonstrate the idea.

PHASE III DUAL USE APPLICATIONS: Each proposal that is submitted under this general topic should have associated dual use commercial applications of the planned technology, process, and concept. The commercial application should be formulated during Phase I. Phase II will require a complete commercialization plan.

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KEYWORDS: Aerial Targets, Missile Scoring, Target Control, Infrared and Electronic Warfare Payloads, Simulation and Modeling, Aircraft Manufacturing, Signal Processing, Antennas, Aircraft Engine

AF02-251 TITLE: Integration of Hypersonic Vehicle Inlets, Isolators and Exhaust Nozzles for Multiple Engine Flowpaths

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop an analytical design and evaluation tool for hypersonic cruise and space access vehicle inlets, isolators, and nozzles

DESCRIPTION: Space access and hypersonic cruise vehicle operating velocity range is so varied that multiple engine cycles with multiple engine flow paths are mandatory. Integration of these flowpaths through highly efficient, relatively lightweight inlets, and exhaust nozzles is a formidable task. This is especially challenging for engines where there can be as many as eight axisymmetric flowpaths that may have to transition from square, round/half circle to an unknown configuration to a planar afterbody. Engine types include turbine-based combined cycle (TBCC) engines, rocket-based combined cycle (RBCC) engines, pulse detonation engines (PDEs), or other possibilities. The first two engine systems are possibly two completely separate systems with varying flow requirements throughout the Mach range. The combined cycle engines will require the design capability of splitting the flow between the two engine types, and again for the individual engines of each type. Current one-dimensional codes, such as the Ram Jet Performance Analysis (RJPA) code, do not provide adequate fidelity. Three-dimensional (3D) analytical design and evaluation tools are needed, and an experimental database is required, to demonstrate the veracity of the design approach. Critical design issues are compact installation, minimizing losses, volumetric efficiency, 3D force and moment effects, high-temperature gas dynamics, finite rate chemistry in the exhaust, and mode transition dynamic analysis. The system shall be capable of analyzing a JP-7 fuel cycle with other fuels being optional.

PHASE I: Complete a search on the existing engine design techniques (software). Develop the flow analysis concept for the flow analysis tool. Present the concepts to Air Force, engine inlet analysis experts, and utilize their comments as appropriate. Identify the potential risks and capabilities of the proposed 3D analysis tool, and identify the expected benefits of the tool over existing analysis techniques.

PHASE II: Develop, demonstrate and validate the proposed concept(s) for realistic applications in the aerospace industry. The tool shall be easy to operate (i.e., pull down menus), and shall include a users guide. Data for a well-understood inlet system design shall be obtained to demonstrate and validate the new technique. A test case shall be run for a TBCC system determining the trades between individual inlets for each individual engine versus split inlets for each different cycle engine pair versus a different cycle split inlet with up to 4 engines of each cycle from 0 to Mach 17. The code shall be modular, and capable of interfacing with existing engine design codes.

PHASE III DUAL USE APPLICATIONS: This technology can be applied to both military and civilian high-speed vehicles (future strike, space access). The technology may at some future date be applied to civilian aviation as a high-speed transport. The highest payoffs could be realized for applications involving commercialization of space and hypersonic transport. Some examples include transport to and from space-based hotels and resorts, and transport across long distances in short time spans.

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1. Curran, T.E., et al, "A Review of Kinetic Energy Methods in High Speed Engine Cycle Analysis," ISABE 91-10, 10th International Symposium on Air Breathing Engines," Nottingham UK, Sep 1991.

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KEYWORDS: Nozzles, High-Speed Nozzles, Variable-Geometry Nozzles, Flow Path, Isolator, Space Access, Airbreathing Propulsion, Combined Cycle Engines, High-Temperature Gas Dynamics

AF02-253 TITLE: Metal Deposition for Locally Tailored Properties

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Demonstrate Feasibility, Identify Payoffs, and Develop Design Data for the Use of Metal Powder Deposition Techniques for Locally Tailoring Properties for Metal Structures.

DESCRIPTION: Metal structures are susceptible to cracking due to fatigue. Additionally, there is often loss of material and associated strength and stiffness due to corrosion effects. These effects are often localized in a structure, concentrated about more intense stresses, often referred to as "hot spots". Hot spots can result from the underprediction of loads or changes in use pattern. These hot spots may result in modifications to the structure. Repairs to the structure are often quite complex because in order to both restore strength and eliminate the "hot spot" the repair must be completed in such a manner as to not create a new, and perhaps worse, problem due to mismatch in property. Deposition used to apply form powder metals may allow the direct replacement of lost material or close a crack allowing local application of a specifically tailored material in order to eliminate hot spots. This approach may also be used in a manufacturing process to directly reinforce on local area in a structural element not requiring such reinforcement elsewhere. Other uses of the ability to deposit tailored material can be visualized. The Air Force Research Laboratory is seeking innovative concepts for the deposition of powder with locally tailored properties for purposes of repair of current or manufacture of future structural elements in order to reduce the cost and structural weight of future air vehicles. Development of this technology will enable precise, local tailoring of properties in metals during cure and or at the point of repair for which the accuracy and controllability far surpasses present state-of-art.

PHASE I: In Phase I, the ability to create an "alloy" by combining different metals in order to achieve several desired properties will be demonstrated through the creation of complex structural elements. The ability to achieve the desired properties will be demonstrated through test. These elements will be selected in such a manner as to develop reasonable confidence in the material performance cost and weight reduction potential.

PHASE II: Phase II will determine the suitability of the deposition process for manufacture and or repair of actual air vehicle structures by fabrication and test, according to a proposed plan, of a more complex aircraft structure. This is a demonstration test, and need not be conducted to the standards of a certification effort.

PHASE III DUAL USE APPLICATIONS: During Phase III, the low cost rapid manufacturing technology will be further developed and transitioned. Potential users could include but not be limited to the aerospace industry, for temporary repair or modification of airframes. Commercial applications include the commercial aerospace, automotive, infrastructure and machine design industries. Specific Air Force applications all heavy airframe structures.

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KEYWORDS: Powdered Metal, Deposition, Designer Alloys, Structural Repair

AF02-254 TITLE: High-fidelity Tools for Three-dimensional Multi-physics Computation

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop software product(s) to insert versatile high-fidelity multidisciplinary methodologies into three-dimensional high-order simulation platforms.

DESCRIPTION: The unconventional design space of future aerospace vehicles demands extensive utilization of multidisciplinary numerical modeling and simulation. Limitations in present computational capability arise both from finite computer processing power as well as accuracy and applicability confines of standard numerical algorithms. One approach to extending computational capability is through the use of highly accurate methods. For example, those exhibiting a minimum order and spectral resolution comparable to fourth-order Pade-type formulas on parallel processing multicomputers. Application of such schemes has so far been hindered by their unstable behavior in practical situations where geometrical and physical considerations dictate the use of nonideal meshes and approximate boundary conditions. Recently, several basic research efforts have overcome these constraints by introducing new elements such as highly-discriminating low-pass filtering and high-order upwinding techniques. Some of these high-order schemes have additionally exhibited superior versatility in solving governing equations describing three-dimensional, multi-disciplinary, and multi-scale phenomena in fluid dynamics (aeroacoustics and direct simulations of turbulence), electromagnetics (signature prediction), magnetogasdynamics (thermal protection in hypersonic flight), and fluid-structure interactions (buffeting and flutter). A careful and systematic analysis with a high degree of ingenuity and innovation together with an emphasis on open-architecture considerations, is required to optimize factors related to the choice of the high-order scheme with those associated with ease of implementation on scalable platforms. Such a study leads naturally to the development of a versatile modular software suite based on common elements of modern research codes and facilitates the high payoff endeavor of technology insertion into current production codes.

PHASE I: Determine feasibility and define scope of the proposed concept(s) for developing a general purpose software suite. Select platform and develop high-order methodology. Identify common elements of production codes suitable for technology upgrades. Develop plans to test software.

PHASE II: Develop software suite. Verify and validate accuracy. Test and document scalability. Demonstrate applicability through a large-scale test problem analysis on selected parallel platform.

PHASE III DUAL USE APPLICATIONS: The large body of proprietary production software currently utilizes standard low-order procedures which incur significant limitations. Considerable opportunity exists therefore for insertion of the high-order multidisciplinary software suite to upgrade the capability of such production codes. From the DoD standpoint, this software suite will make feasible presently unachievable proof-of-concept studies utilizing revolutionary multidisciplinary technologies.

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KEYWORDS: High-order Computational Methods, Multi-disciplinary Simulation, Turbulence Simulation, Computational Electromagnetics, Magnetogasdynamics Simulation

AF02-255 TITLE: Reactive Flow Control for Virtual Aerodynamic Shaping

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: To develop and demonstrate reactive control mechanization concepts to improve the aerodynamic performance of air vehicles.

DESCRIPTION: Given the many successes in open-loop aerodynamic flow control, the use of feedback combined with flow control actuation makes virtual aerodynamic shaping an achievable goal. Virtual aerodynamic shaping involves manipulating the flow field so that it reacts as if it encounters a geometry other than what is physically

present. Achievement of this goal would allow air vehicle designs to be optimized for criteria other than aerodynamic performance (e.g., radar cross section or embedded sensor effectiveness) without adversely impacting – or perhaps enhancing – aerodynamic performance (e.g., lift-to-drag ratio). Such flow field manipulation may also allow for the partial or complete replacement of hinged flight- control surfaces through the manipulation of sectional lift properties.The objective of this research is to demonstrate the meaningful manipulation of the flow field over a generic three-dimensional (3-D) body, including the ability to control incipient separation and reattachment throughout flow conditions typical of an operational flight envelope. An integrated system of sensors and actuators coupled through feedback control is desired. A successful program would be strong in each and all of the following areas: aerodynamics, actuators, sensors, and control law design. Consideration should also be given to air vehicle integration, including modeling of the aerodynamic effects of the control concept, control law design for the aircraft-actuator integrated system, modeling and allocation of control power, overall control architecture, and impact on the overall air vehicle design. Both Micro Elecro-Mechanical Systems(MEMS) and non-MEMS technologies will be given equal consideration. The most appropriate feedback control technique will depend on the overall system architecture, but distributed parameter control, robust control, learning control and/or other advanced control technologies may be required to meet the large flight envelope requirement. The demonstration of the system is to be carried out through high-fidelity CFD simulation, wind tunnel testing, and/or flight testing representative of the entire design envelope.

PHASE I: Phase I shall consist of the initial design, integration and demonstration of a pilot reactive flow control system. The successful system shall demonstrate the ability to manipulate the flow field of a two- dimensional (2-D) or 3-D body on demand via the control system. This demonstration may be conducted either through simulation or wind tunnel experiment over a subset of the ultimate design space.

PHASE II: Phase II shall consist of the design, integration and demonstration of the reactive flow control system developed in Phase I over a range of flow-field/flight conditions. The successful system shall be robust toward changing flow state while maintaining the ability to manipulate the flow field over a 3-D body on demand via the control system. Preference shall be given to a demonstration that balances both simulation and physical experimentation.

PHASE III DUAL USE APPLICATIONS: All classes of air vehicles may benefit from this technology. This capability will ultimately be useful for improving the aerodynamic performance of nonaerodynamically-optimized designs as well as enabling hingeless flight control. Further, significant duel-use potential for air, ground, and water-borne vehicles exists for this technology.

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KEYWORDS: Reactive Flow Control, Flow Separation Control, Feedback Control, Control Law Design

AF02-256 TITLE: Distributed, Embedded Sensing for Quasi-Static Shape Control of Wings

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: To investigate and develop methodologies for shape determination of deformed wing sections using state-of-the-art distributed and embedded sensor devices.

DESCRIPTION: This topic addresses deformation shape sensing and mapping of wing structures for applications such as airfoil shaping, wing warping or twisting, or other adaptive structures applications where knowledge of the true deformation shape of the wing is required. This information can be fed back to the controller for closed-loop control of aerodynamic or aeroelastic phenomenon, or can be provided to other subsystems for performance adjustment (such as embedded antenna performance). In an airborne environment, these measurements must be made in-situ, which

suggests the use of distributed and embedded sensors. This system requires a combination of hardware, including the sensors themselves, wiring, signal conditioning, associated electronics, and processing equipment, as well as software, which consists of signal processing and data reduction algorithms. In addition, the observability of a particular shape is dependent on the type and spatial resolution of the sensors. Therefore, techniques for determining the optimum sensor number and placement are also important, based on observability requirements of the expected deformation space.

PHASE I: Phase I will concentrate on determining a representative aircraft wing type to use in the study, determining the type of sensors to be used, optimizing the number and placement of sensors, and developing an algorithm to combine the data from the suite of sensors to measure the deformed wing shape.

PHASE II: In Phase II, it is envisioned that a scaled wing section will be fabricated with the embedded sensor suite, and the system will be demonstrated as a static load test using expected ranges and types of aeroelastic and active flow control wing deformations.

PHASE III DUAL USE APPLICATIONS: In Phase III, additional testing of the shape sensing system will be conducted. Alternate air vehicle platforms could also be investigated. Nonmilitary uses of the technology include drag minimization and performance enhancement on commercial aircraft, as well as sensing and control of precision deformable antennas and shape sensing and control of inflatable antennas and other inflatable structures.

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KEYWORDS: Sensor Fusion, Optimal Sensor Placement, Wing Deformation, Shape Sensing, Embedded Devices

AF02-257 TITLE: Biologically Inspired Autonomous Control Technologies

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop affordable, task oriented, airborne agents using technology based on natural systems.

DESCRIPTION: The Air Force is exploring the development and deployment of revolutionary unmanned air and launch space vehicles. These vehicles may be operated in isolation, in multi-vehicle groups, swarms, or as part of a cooperative force structure involving large numbers and varieties of both manned and unmanned vehicles. However, there are a several practical considerations that need addressing before flying autonomous systems can be fielded. Software Cost: current multi-agent telerobotics research is heavily vested in artificial intelligence techniques that require large software algorithms, huge processors, and global information availability. Projected program size for even simple multi-vehicle autonomous control system operational flight programs range from 1,200,000 to 4,500,000 lines of higher-order language code, an order of magnitude beyond today's manned aircraft programs. Flight certification of current software costs roughly $500 per line of code, meaning that anything more than simple autonomous control system software could be prohibitively expensive. Information Requirements: in addition, the same state-of-the-art autonomous agents based on artificial intelligence rely on the fact that each agent knows what all the other agents are doing all the time, in other words, global knowledge is required. This quickly results in impractical communication schemes due to huge information bandwidths for anything but the simplest of tasks (communication requirements grow exponentially with the number of nodes in the system), not to mention the information security and low-probability-of-intercept (stealth) issues. New innovative research based on natural systems hold the promise of reducing software costs, processing requirements, and explicit communications in multi-agent autonomous systems. For instance one could use stigmergy (agents interacting through the task or environment without explicit communications). Social insects use this as one method of communication, such as cooperative transport, locating food, or building nest structures. Using stigmergy, complex tasks can be completed without "broadcast" of information by the individual agents. Applying this to autonomous vehicles could result in significant reductions in communication requirements. Another example could be emergent behavior – complex behaviors that arise from interaction of simpler micro-behaviors. Seemingly complicated group behaviors, such as bird flocks, fish schools, and even entire social insect colonies are simply the result of an integration of much simpler behaviors interacting is such a way to produce the complex behavior. Using emergent behavior complex tasks can be completed without explicitly telling each individual what the overall goal is, or how the individual specifically fits in. Applying this to autonomous vehicles could result in enormous decreases in code size and processor throughput requirements. The integration of natural

systems characteristics promises to drastically reduce the complexity of distributed autonomous systems, exhibiting simplicity, robustness, and flexibility while minimizing explicit communications. Autonomous vehicle applications using traditional artificial intelligence hindered by the computational and communication requirements could be practical using natural systems technology. The goal is to leverage prior technology development to establish requirements, designs and architectures in which natural systems technology can be used for flight critical control functions. Behaviors developed need to accommodate the full range of vehicle tasks including terminal area operations, formation management, deconfliction, and other cooperative operations, while considering affordability for flight critical application. Note that this solution does not have to be exclusively software oriented. Innovative analog hardware solutions will be considered. It is also desired to understand the trade–offs and impacts bio-inspired technology has on coordination strategy, local versus global information availability, communication requirements/degradation, and other systems-of-systems control issues such as heterogeneity. All concepts must be sufficiently generic for applicability to wide varieties of distributed autonomous systems. Technical parameters to consider include software reduction – show how innovative technology reduces the line count (lines of higher-order code) and complexity (sub-function calls) while maintaining system performance, and information/communication requirements – show how technology reduces system information and/or communication requirements. Information can be measured in Megabytes of storage and communication in both bandwidth (Hz) and reliability (acceptable drop-out rate).

PHASE I: Define the proposed concept, outline the basic principles, and establish a method of solution. Develop metrics for comparison with traditional artificial intelligence methods. Choose at least one particular multi-agent unmanned vehicle application that is to be used for analytic development of the control technique and experimental validation. This application should be one already accomplished via existing methods, and should be for aerial vehicles. Determine the risk and extent of improvement over existing methods.

PHASE II: Build a prototype application of the equipment or software. Demonstrate the advanced technology under actual engineering conditions OR demonstration under simulated flight conditions. Verify/update initial risk and improvement predictions.

PHASE III DUAL USE APPLICATIONS: The technology developed under this effort will be applicable to a wide variety of autonomous agents including air, space, land, and sea vehicles. In addition, the methods and tools will be applicable to communication control and protocol, data analysis, and distributed control (and robotic) systems used in commercial manufacturing, process control, and material handling systems. The methods developed will enable many groups of systems to interact affordably, autonomously, and cooperatively with minimal communications and computational requirements.

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KEYWORDS: Self-organization, Biomimetics, Swarm Intelligence, Behavior-based Control, Intelligent Behaviors, Emergent Behaviors, Stigmergy, Distributed Control, Intelligent Agents, Multi-agent System, Decentralized Control, Cooperative Control, Swarms, Artificial Life, Artificial Intelligence, Robot Teams, Distributed Autonomous Systems

AF02-259 TITLE: Affordability Development and Integration into Simulation-Based Research and Development (R&D)

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop and integrate a cost model into the simulation-based research and development(R&D)architecture for assessing emerging paradigm-shifting technologies.

DESCRIPTION: Revolutionary cost prediction models, not based on extrapolation of current technology trends, are needed to adequately evaluate new, paradigm shifting technologies. These are needed since existing, traditional cost models do not provide adequate insight into the impact inclusion of an emerging or maturing technology will have on the affordability of a new weapon system. Typically, these models estimate the cost benefits or penalties of an emerging technology by using prediction methods based upon component weight or number of lines of software code extrapolated from the current state of the art. Such techniques may be adequate for evolutionary technology advancements but generally completely miss the mark for revolutionary technology advancements – such as paradigm shifts. More and more designers, analysts, and planners are utilizing the output from these cost-estimating tools to establish priorities in the technology investment selection process. Limited funding and manpower resources are forcing technology planners to prioritize the development of these technologies very early in their maturation cycle; as early as during conceptual or preliminary design. Performance models exist and are currently being utilized in flight simulations to evaluate the performance of air vehicles at the vehicle level for both military and commercial air vehicles. These air vehicle level performance models have the capability of being rapidly reconfigured to evaluate the effectiveness of air vehicle configurations for a matrix of configurations and relevant mission environments.

PHASE I: The goal of this research effort is to evolve and demonstrate an architecture that supports parametric studies of cost as an independent variable (CAIV) for inserting maturing or emerging technologies into next-generation air vehicles. This architecture will draw from the latest advances in cost estimating, cost modeling, life cycle cost, total ownership cost, operations research, and decision theory. It will place maximum emphasize on the use of nontraditional techniques and tools in the performance of these parametric studies.

PHASE II: The goal of this research effort is to formulate and demonstrate a CAIV model from the architecture developed during Phase I. Approaches leading to the creation of an innovative, user friendly model that automatically translates simulation results into high-fidelity formats for next-generation air vehicles are sought.

PHASE III DUAL USE APPLICATIONS: The military systems applications include a rapid- product development capability for supporting military technology development and weapon systems development. The use of such a simulation capability to aid the laboratory in technology investment by objectively evaluating future system performance and affordability is one of the core components of simulation-based research and development. Commercial systems applications include links to the aerospace and automotive industries. Performance level models and affordability tools linked to detailed design models would lead to reduced product development time.

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5. Ortgiesen, Randall G. "Infrastructure Systems and Cost Ownership," Master Thesis, Purdue University, ADA240577, August 1991.

KEYWORDS: Cost Modeling, Life Cycle Cost, Total Ownership Cost, Cost Estimating, Operations Research, Decision Theory, Simulation-Based Research and Development

AF02-263 TITLE: e-Learning and Aptitude Evaluation Through A Web-based Training Framework

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop a framework that would allow any DoD depot to a) evaluate a worker's training needs and b) provide that training in the most efficient environment

DESCRIPTION: With a maintenance work force of over 700,000 personnel, the Department of Defense is seeking to develop effective programs for training to make this workforce more efficient. Moreover, recent data shows the average age of a DoD worker in the maintenance depots to be close to 50. While the depots are replenishing their aging workforce, they need the required training tools to quickly bring the new generation of workers up to speed.e-Learning extends learning beyond traditional classrooms to workplaces and supports life-long training. Over the last few years, e-learning has migrated more towards the Web, providing a wide range of services anytime, anywhere, to anyone. Such Web-based training is generally broken down into asynchronous and synchronous learning. In asynchronous e-learning training takes place in different time frames and trainees access information at their convenience. The synchronous training, on the other hand, takes place for all students at the same time and information is accessed instantly. The latter form of e-learning provides more interactivity, whereas the former provides more flexibility.A web-based training framework must a) provide an evaluation environment such that the educational needs of any depot worker is quickly determined, and b) provide a web-based tool for accessing any training material on any platform and in any environment. The evaluation center for the framework must be supported by a database of relevant questions that are given in a random manner and are graded by the system automatically. The training part of the framework must be easy to use and easy to implement. The framework must also follow technical standards such as Advanced Distributed learning (ADL), (website: http://www.adlnet.org) which is supported by DoD. Standards like ADL define high-level requirements for educational content such as content reusability, accessibility, durability, and interoperability. Moreover, the framework must be designed for the "lowest common denominator" such that anyone using any platform and in any environment can take the evaluations and get access to the desired training material. Key objectives to be met are an analysis of emerging network-based technologies to improve band-width of video use over the shop internets, capture of workforce knowledge for reuse to young workforce, stimulate large-scale collaboration environment across organizations, and use of ADL standards to provide a repositories of reusable, shareable, and platform-independent training material.

PHASE I: Research and analyze which type of e-learning (synchronous or asynchronous) is more effective for the depot personnel based on the above technical objectives. Identify and select a shop area within Tinker AFB and provide a conceptual demonstration of a web-based shop floor portal for the direct training needs of a shop user based on his certification, work being performed, and skill levels. Provide data to demonstrate that proposed solution will meet current network capacity.

PHASE II: Develop a prototype at Tinker AFB and use the metrics defined in phase I to demonstrate its success. Also, prepare a detailed report describing the challenges faced during the pilot implementation, and the methods used to deal with them, and present it to appropriate individuals.

PHASE III DUAL USE APPLICATIONS: The implemented framework could be utilized for training by any commercial or educational institution interested in e-learning.

REFERENCES:
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2) "E-learning makes the grade" INFOWORLD, July 24, 2000,http://www.infoworld.com/
3) "Just-in-time Knowledge: A three-part special report on e-learning" KNOWLEDGE MANAGEMENT, August 2000
4) "Bridging the Gap: Information Technology Skills for a New Millenium" Information Technology Association of America, July 2000.
5) ADL Website "http://www.adlnet.org"

KEYWORDS: e-Learning, Web-Based Training

AF02-264 TITLE: Simulation of Repair and Rebuild Processes

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop a Monte Carlo simulation model of some process in a depot shop.

DESCRIPTION: Many companies use Monte Carlo simulation of their processes to detect and eliminate inefficiencies. These processes include but are not limited to:1. The flow of parts across departments on a factory floor, done to reduce the amount of work in process;2. The flow of chemicals through a refinery;3. The movement of products between factories and from factories to the customer, done to ensure the timely delivery of product to the customer.A Monte Carlo model consists of elements, each element representing one item at the level of resolution of the mode. The elements in a high-resolution model would represent the activities of individuals, single parts, single machines, single conveyors, and single trucks. The elements in a lower resolution model would represent the activities of a department of several individuals, a factory, complete products, and a fleet of trucks.If two elements in a model represent a part casting and a drill press, then the process of using the drill press to drill holes in the casting is simulated by computing how long it would take to mount the part in the drill press, remove the metal by drilling, and remove the part from the drill press. During this time, the element representing the part is not available to other machine tools and the element representing the drill press is not available to process other parts. The model does not actually drill the holes in the part, but simulates this drilling process by computing the time delays, labor requirements, and other costs.A completed model will have many elements, all the elements interacting with each other. The face mill is idle because the part is still being drilled in the drill press. If the face mill is idle too much of the time, the model would reveal this fact and help determine the causes. The model can be easily modified to determine the impact of proposed fixes or modifications to the process.Applied to the operations at a depot shop, the real benefits of this approach become evident during the phase when the depot personnel gain understanding of how their shop actually functions by digging for answers to questions raised in order to complete the model.

PHASE I: Perform a feasibility analysis to select a DoD depot and an appropriate process from that DoD depot. This will involve visiting the depot, presenting the capabilities and limitations of Monte Carlo Simulation, and discussing the various attributes of the possible processes with the appropriate personnel from the depot. Then, perform the necessary research and development of a Monte Carlo Simulation concept package that demonstrates concept with defined metrics for assessing the requirements.

PHASE II: Develop the prototype based on Phase I analysis and defined requirements and test the developed model (the prototype) in a real environment and prove its viability to the management of the depot using the metrics set in Phase I. During this phase, there will be a lot of discussion of the attributes of the processes with the appropriate personnel from the depot. Prepare a detailed final report on the lessons learned and implementation procedures. Based on results, tailor the completed prototype for commercialization and availability for full implementation.

PHASE III DUAL USE APPLICATIONS: With minor modifications, the implemented model could be utilized in any industry.

REFERENCES:

1)"Short Term Scheduling Using Discrete Event Simulation" Texas A&M University, October 1996,http://tamcam.tamu.edu/Research/short.htm

2)"Contract Aircraft Repair Lean Logistics" Robins Air Force Base, October 1996,http://www.fas.org/man/dod-101/sys/ac/docs/car.htm

3) "Introduction to the WITNESS Visual Interactive Simulator and OLEII Automation" AT&T Istel, Inc., July 1996.http://www.ukans.edu/wsc96/htmfiles/sm014.htm

4) "Witness Technology for Knowing" Lanner Corporation, October 2000,http://www.lanner.com/corporate/Support/newfeatures.htm

KEYWORDS: Repair Simulation, Monte Carlo Model

AF02-265 TITLE: Aircraft Wiring Characterization, Tracking, and Testing System (AWCTTS)

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop a low-cost, light-weight, easy-to-operate portable testing system (AWCTTS) for characterization, monitoring, and testing of aircraft wiring.

DESCRIPTION: The USAF has a fleet of aging aircraft. The electrical wiring on these aircraft is in various stages of wear and aging. This wiring is inspected at regular intervals, however many areas are either hidden and/or inaccessible. Chaffing, aging, heat induced cracking in insulation, and damaged connector bodies can go undetected until it causes an electrical failure. This project seeks innovative research to develop a new technology to characterize, monitor, and test aircraft wiring systems. This project should address: (1) ability to characterize the wiring systems of multiple aircraft platforms by weapon system, tail number, wire bundle, individual wire, and connector all by part number. (2) Ability to track, recharacterize, and compare characteristics of wire bundles, individual wires, and connector, all by part number as they age. (3) Ability to locate failures and damage to include but not limited to: shorts to ground, shorts to other wires, breaks, partial breaks, chaffing, cracking in insulation or connectors, dirty, worn, bent or broken contacts. (4) the portable AWCTTS would be easily transportable between aircraft by a trained technician. (5) Tester shall be modular, expandable, and flexible to allow for insertion of faster processors, and expanded volatile and nonvolatile memory, etc. (6) Functions shall be software programmable and PC/Laptop based.

PHASE I: Conduct research to determine feasibility of developing an AWCTTS tester with the following target capabilities: (1) low cost, (2) simplified operation and output, (3) high speed operations, storage and retrieval of data and (4) portable. Determine any required additional test and characterization software and the database and parameters to be used to store, display, analyze and manipulate wire harness characterizations. Develop a planned approach for completing the rest of the system final hardware and software configurations. Demonstrate its capabilities with several types of wire bundles of different lengths, cable types, etc.

PHASE II: Develop the AWCTTS design into a prototype unit, which meets the Phase I target capabilities. Design the tester to provide the user; flexibility, ease of use, instant visual recognition, data input integrity, and the ability to capture and transfer test results. Verify the test set capability on an operational aircraft weapon system. Deliver a working prototype with all software programs, and hardware drawings.

PHASE III DUAL USE APPLICATIONS: This topic is applicable to a wide variety of applications. It is particularly relevant to commercial aircraft wiring, plant maintenance, industrial process control, medical and other applications where system performance is critical and precise and quick repair is needed.

REFERENCES:

KEYWORDS: Automatic cable testing, Wire harness characterization, Aging Aircraft, Reliability and Maintainability

AF02-266 TITLE: Active Bus Analysis and Failure Forecasting

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop hardware and software for automated testing equipment for active bus analysis.

DESCRIPTION: Conduct research to determine feasibility of developing a technically advanced and automated testing system to exercise and monitor active bus operations for the purpose of identifying current bus failures, marginal bus component performance, and predict potential failures on electrical bus systems. Bus wire insulation degrades by chaffing and polymer breakdown due to flight stress, maintenance wear, and age. These conditions cause arcing, shorts, high impedance leaks, and intermittent grounding of communication signals. Bus connectors and pins/sockets loosen, break, and bend during maintenance causing unreliable electrical contact. Matrix relays degrade from both weakened electromagnetic flux for contact, and contact pitting/corrosion. This relay degradation ultimately results in unreliable signal routing operations. Bus transformers often short-to-ground, change impedance/resistance values, and develop improper ratios due to flight stress, cracking, water intrusion, and corrosion. These failures cause noise, lost signal data, and other degradations to bus communication abilities. Degraded buses provide weak signal communications between Line Replaceable Units (LRUs) and bus controllers; this heightens the occurrence of bus faults causing erroneous errors that indicate LRU failures. Degraded bus operations diminish reliable electronic communication among aircraft systems; therefore the mission safety and mission capability is compromised. Poor bus communications that induce erroneous LRU faults and other false indications incur misdirected troubleshooting and

maintenance, causing lower FMC Rates, longer aircraft down-time, higher technician workload, and significantly increased maintenance costs at the operations, intermediate, and depot levels. All unsubstantiated and bogus fails caused by degraded bus operations skew trend analysis and failure forecasting systems that engineering and management use to ultimately reduce total ownership cost of the airframe. Bus maintenance increases proper bus operation and reduces unsubstantiated bogus fails caused by degraded bus components; therefore only real and actual MFL and LRU fail data is input to failure forecasting systems. The refined input data for failure forecasting allows more accurate predictions, which in turn produces more reliable analysis for leaner logistics and advanced maintenance intelligence. Current equipment has proven to be technically inadequate for thorough troubleshooting and fault identification (i.e., no active bus testing capability, improper testing frequencies, no testing frequency flexibility, non-user friendly test equipment, extreme learning curves even for minimal technician familiarity, minimal testing automation, inadequate ability to test for marginal or intermittent components).

PHASE I: Conduct research to develop hardware configurations and intelligent user-friendly software for automated testing of active aircraft buses. This technology should address the following areas: (1) aircraft maintenance history data capture, (2) software engineering for intelligent test programs sets, (3) history data basing for maintenance and failure trend analysis, (4) accurate aircraft bus and electrical systems fault forecasting, and (5) accelerated aircraft bus and electrical system fault isolation.

PHASE II: Develop and demonstrate a prototype system that will meet or exceed the objectives of phase I. Conduct prototype effectiveness on selected aircraft for documentation of prototype operation, and the effects on aircraft failure forecasting input data.

PHASE III DUAL USE APPLICATIONS: The development of active bus testing technology can be adapted to support all military, government, and commercial air frames, technologically advanced naval vessels, command and control center electronics, and other federal, state and local governments that use equipment with similar type electronic bus systems. Commercial computer systems have a broad array of bus and wiring systems for communications, which provides an enormous potential commercial market.

REFERENCES:

1. Cynthia Furse & Randy Haupt, "Down to the Wire", IEEE Spectrum, FEB 2001, pp 35-39

2. MBFI World Wide Conference 2000, Hill AFB, UT, JUN 00

3. Proud Falcon Report, 93rd Fighter Squadron, Homestead AFB, FL, OCT 1997

4. Mako Proud Falcon Report, 93 FS Homestead AFB, FL, NOV 2000

5. Proud Falcon Successes Report, Falcon Sq. Nellis AFB, SEP 1994

KEYWORDS: Aircraft Fault Analysis, Preemptive Maintenance, Aircraft Failure Forecasting, Reduce Total Ownership Cost, Mux Bus Maintenance

AF02-267 TITLE: Sound Technology For Test And Diagnosis

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop and implement methods for analyzing component defects using Sound Technology.

DESCRIPTION: The purpose of this topic is to focus on testing and diagnosing failures in printed circuit board components utilizing sound/ultrasound technology. The topic specifically focuses' on using Sound Technology hardware and software methods to test printed circuit board components for defects. Sub-micron analysis could be achieved utilizing reflective technology. Sound reflection is proportional to a material's density creating a time (depth) dependent signature that can isolate problems at their level of occurrence. It should be possible to identify defective component substrates utilizing reflective sound technology. The technology could focus on methods of scanning circuit boards with a sound wave component to determine defects. Dynamically controlled motion is preferred so a 3-D measurement can be achieved, and a clear view of a component's structure is visible. New software allows the stacking of multiple images for multi-dimensional analysis.

PHASE I: Conduct research and determine feasibility of focusing on hardware and software methods to analyze component defects using Sound Technology.

PHASE II: Develop a detailed prototype design to create and implement the technology of Phase I.

PHASE III DUAL USE APPLICATIONS: The technology is applicable to a wide variety of applications and processes. It is particularly relevant to aircraft, plant maintenance, industrial process control, medical and other applications where system performance is critical and repair should be quick and precise.

REFERENCES:

KEYWORDS: Test & Diagnosis, Sound Technology, Hardware and Software

AF02-268 TITLE: Advanced Composite Materials Replacement on Metal Structures/Shelters

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Provide and identify suitable composite materials to replace the existing heavy and corrosion-prone materials in metal-based structures or shelters.

DESCRIPTION: DOD spends millions of dollars every year to repair and refurbish numerous metal structures or shelters located all over the world. Composite materials, which are not prone to corrosion, have the potential to offer a lighter weight replacement material for structure or shelter, thereby reducing cost. The proposed objectives for this composite material replacement process are as follow: (i) Reduce manufacturing costs (ii) Reduce shelter foot-print to comply with the Air Force Expedition Force requirements (iii) Shall be environmentally safe for human occupation per ASTM E1925.

PHASE I: Conduct research and determine feasibility of replacing current metal-based materials with composite materials in the manufacturing process with the following target capabilities: (i) The materials shall be of low cost and readily available (ii) The materials shall be non-toxic and fire resistant/retardant (iii) The structure or shelter main components (such as I beam, wall panels, trusses etc.) shall be made of 100% composite materials (to minimize galvanic corrosion), and these components shall have the same or greater strength as their metal counterparts (iv) Shall meet current requirement of the metal structure or shelter as specified in ASTM E1925 (v) Final total life cycle cost should be significantly less (50% or better) than a comparable metal structure or shelter.

PHASE II: Design and develop a process to construct a commercially viable composite structure or shelter. Structural analyses by computerized simulation shall be conducted to ensure the structure will meet or exceed ASTM standard E1925. Build and test a prototype composite structure or shelter using the proposed process in according with ASTM E1925.

PHASE III DUAL USE APPLICATIONS: The proposed composite structure or shelter will have numerous benefits to the military and industrial communities. They are as follow: Commercial trailers for trucking and railway. Offshore applications for ships, shipping containers, service vessels, platform, and undersea facilities etc. Composite structures for residential dwelling as well as commercial service "bare base" hangar. Replace numerous existing corrosion-prone and aging DOD metal shelters and containers.

REFERENCES:
1. ASTM E1925, Specification for Engineering and Design Criteria For Rigid Wall Relocatable Structures.
2. Natick Soldier Center, DOD Standard Family of Tactical Shelters, January 2000
3. Advanced Composite Structures: Fabrication and Damage Repair, Abaris Training, May 1998.
4. Paints, Coatings, and Corrosion Control in Manufacturing, University of Wisconsin-Madison, March 1999.
5. MIL-STD-1472D, Notice 3, Human Engineering Design Criteria for Military Systems, Equipment and Facilities.

KEYWORDS: Composites, structure or shelter, ASTM E1925, reduce foot-print, environmentally safe

AF02-269 TITLE: Performance Based Support Model

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop new and innovative affordable processes to logistically support systems and equipment developed under Performance Based Acquisition (PBA) policies.

DESCRIPTION: Department of Defense PBA policies have provided new opportunities to reduce defense costs while taking advantage of commercial advances in technology. The resulting Flexible Sustainment Initiative by the Joint Aeronautical Commanders has extended these policies to include the logistical support of fielded and mature weapon systems. In the past, the government has paid a premium to repair and replace high failure assemblies and components with identically configured technology, which tended to exacerbate both cost and obsolescence problems. The new business practices that incorporate performance based concepts, provide opportunities to reduce total ownership cost by inserting current technology that increases reliability and performance, while eliminating obsolescence problems. These new opportunities also present some unique challenges in logistic support. Assembles and components procured with a performance based specification may have different configuration and parts from the original equipment and therefore have different support requirements. Traditional logistic practices are based on identical configuration, internal operation, and parts for replacement equipment at all levels. As technology evolves, system sustainment managers are faced with the challenge of supporting totally integrated functions comprised of firmware, hardware and software, that require rigorous integration testing to ensure they operate seamlessly with the entire weapon system. The new paradigm requires only identical form, fit, interfaces and functional equivalence. In each case, the benefits of PBA must be optimized in terms of cost, reliability, performance and obsolescence. New logistic support process models are required for the functionally equivalent equipment that will continue to be procured under PBA policies. Research is required to develop new process models to evaluate the most mission effective and cost efficient means to logistically support equipment and replenishment spares acquired in the PBA environment. The research should explore new ways to detect degrading performance prior to failure, and alternatives to the traditional integrated logistic support functions of provisioning and resupply, from a cost/benefit perspective. It should also consider the evolving concepts of an autonomic supply system envisioned for the joint strike fighter.

PHASE I: Conduct research and focus on identifying new logistic support process models. Develop one or more models that will demonstrate their effectiveness. Develop detailed design and evaluation criteria for each model.

PHASE II: Develop a prototype to demonstrate and evaluate methods defined during Phase I.

PHASE III DUAL USE APPLICATIONS: Commercialization will be based on the ability of the process models to support PBA integrated logistic support processes. Significant government and commercial markets exist for this technology in industrial processes. The product will be a software Decision Support System (DSS) product that considers cost and responsiveness. The PBA products that enter the DoD inventory through acquisition reform, employ new technology, which is typically much more reliable.

REFERENCES:
1. Joint Logistics Commanders Performance-Based Business Environment (PBBE), Flexible Sustainmnet Guide, August 1997.

2. "Final Report for the JAST Advanced Strike Integrated Diagnostics (ASID) Concept Definition and Design (CDD)," Joint Advanced Strike Technology Program TML - Advanced Integrated Diagnostics, Arlington, VA, 1996.

3. F-16 Falcon Flex Guide, Ogden Air Logistics Center, F-16 Management Directorate (00-ALC/LF), Hill AFB, UT, June 30, 1998.

KEYWORDS: Performance models, Acquisition, Flexible Sustainment, Logistics Support

AF02-270 TITLE: Advanced Molecular Coating Process

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Provide a low-cost, effective process to stop corrosion on any surface.

DESCRIPTION: DOD spends billions of dollars every year to repair/refurbish equipment/shelters/weapon systems due to the corrosion problems that caused by exposure to the environment, especially severe weather such as high humidity and salty coastal air. There are many current coating techniques that can be used (conventional painting, powder

coating, electro-plating, composite coverings etc.), but some of these processes are not environmental friendly, required intensive preparations, and none offer long-term protection. This project seeks a low cost coating process that will offer long-term protection against the above problems. Additional objectives are as follow: (1) The process shall be non-toxic & environmental friendly, (2) it shall be easy to apply (using conventional means) and storage, (3) and it shall be easy to use at the field maintenance level.

PHASE I: Conduct research and determine feasibility in designing a low cost coating formula with the following target capabilities: (1) Provide corrosion protection for major DOD weapon systems (shelters, ammunitions etc.), (2) the coating formula shall be able to work with different type of substrates (bare metal & painted surface etc.)

PHASE II: Develop a commercially viable prototype coating product, which will meet or exceed all EPA guidelines for coating materials. Proof of concept to be proving on a wide variety of test subjects under severe weather condition in different remote area.

PHASE III DUAL USE APPLICATIONS: The proposed coating process will have numerous benefits to the military and industrial customers as well as the environment. They are as follow:- Applications on machinery exposed to severe coastal weather.- Off-shore applications for freighters, service vessels, platform, and undersea facilities.- Replacing toxic electro-plating processes for corrosion control purposes.

REFERENCES:
1. ASTM E19252. Natick Soldier Center, DOD Standard Family of Tactical Shelters, January 2000

KEYWORDS: Coating, Corrosion, low cost, Corrosion Inhibitors

AF02-272 TITLE: Semi-automatic or automatic development of Test Program Sets (TPS) without a board model using hardware reconstruct

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop and implement automated methods to create a TPS without using a board model.

DESCRIPTION: Standardized model-based simulation methods presently used to develop Test Program Sets, which are used for testing and repair of aircraft avionics systems, are problematic and high cost. Board model methods use theoretical philosophies that endeavor to duplicate the actual functionality of the Unit Under Test (UUT). Test Program Sets (TPS) for UUTs should be developed automatically or semi-automatically without using a board model of the actual avionics hardware. Applying techniques to perform TPS development using random generation of stimulus signals and monitoring a typical response from the actual UUT hardware can be used to determine UUT functionality. Hardware modeling presently exists to perform UUT duplication, so random but controlled pattern sets can be applied and the responses monitored to create a TPS. There are systems available to reconstruct or duplicate a hardware configuration on a test platform. A software method and hardware configuration needs to be developed to create Test Program Sets (TPS) automatically or semi-automatically.

PHASE I: Conduct research and determine the feasibility of a software method to control Automatic Test Equipment (ATE) instruments and a hardware duplicator to automatically or semi-automatically develop a TPS.

PHASE II: Develop a prototype software program to control Automatic Test Equipment (ATE) instruments and a hardware duplicator to automatically or semi-automatically develop a TPS.

PHASE III DUAL USE APPLICATIONS: The technology underlying this topic is quite generic, and is applicable to a wide variety of applications and technologies. It is particularly relevant to aircraft and plant maintenance, industrial process control, medical, and other applications where large numbers of diverse signals are monitored, and overall system performance is characterized through the interpretation of the combination of signals, in addition to the discrete interpretation of individual signals.

REFERENCES:
SYNOPSIS www.synopsys.com/products/lm/hw_models/hw_systems.html

KEYWORDS: 1. Automatic Test Equipment 2. Stimulus devices 3. Sensors 4. UUT Hardware Imitators 5. Hardware Models

AF02-276 TITLE: Compact Hydrogen Storage using Metal Hydride

TECHNOLOGY AREAS: Ground and Sea Vehicles

OBJECTIVE: Research and develop innovative methods to store hydrogen on-board vehicles and ground support equipment using a metal hydride, cryogenic hydrogen, or other innovative technology such as graphite nano fibers.

DESCRIPTION: A major drawback to using hydrogen to power a fuel cell is storage procedures. Current methods of storing hydrogen in a gaseous or liquid form do not offer the energy density of conventional gasoline per unit volume. This leads to a host of problems. The goal of this SBIR project is do applied research that will gain knowledge and understanding necessary to produce a useful method to store Hydrogen using a metal hydride or other high-density hydrogen medium. The medium will be deployed on a vehicle or ground support equipment to power a fuel cell and should strive to provide comparable energy density per unit volume to gasoline. The technology must also demonstrate a reasonable re-fuel rate.

PHASE I: Research will determine which particular hydride or other medium will result in the desired energy storage density. Integration of this technology to the ground support equipment must also be explored. The study will investigate existing gravimetric, volumetric and refueling parameters with improved storage performance parameters.

PHASE II: Develop a prototype storage unit using the metal hydride or other technology to produce the desired energy storage density and other parameters.

PHASE III DUAL USE APPLICATIONS: The storage device would provide a leap forward in providing a commercialized fuel cell power generation for aviation and other transportation industries. While fuel cells are coming at a rapid rate we must be ready with the technology to provide for their fuel.

REFERENCES:
1. MSGT Robert Wertz, http://www.mountainhome.af.mil/AEFB

KEYWORDS: Metal Hydride, Fuel Cell, Hydrogen, Electric Vehicles, and Graphite Nano Fibers

AF02-277 TITLE: Micro JP8 Fuel Reformer

TECHNOLOGY AREAS: Ground and Sea Vehicles

OBJECTIVE: Research and develop a miniature JP8 Hydrogen fuel reformer to produce high quality Hydrogen.

DESCRIPTION: Currently, efforts are underway to reform JP8, the single battlefield fuel, into hydrogen for use in fuel cells for power generation. Present day reformers are large, heavy and provide little commercial or warfighting potential due to limited mobility. This SBIR project will minimize JP8 reforming while maintaining production levels of 150 cfm @ 5000 psi of high quality hydrogen. The reformer must fit on a light duty (½ ton or ¾ ton) truck or vehicle and must be able to be off loaded with the use of heavy machinery.

PHASE I: Research the feasibility to produce a JP8 reformer with the hydrogen production capability as well as the mobility requirements stated in the description.

PHASE II: Develop a prototype for initial test and evaluation of this new technology.

PHASE III DUAL USE APPLICATIONS: Since JP8 is one of the most difficult fuels to reform into hydrogen, making this technology mobile will allow it to be taken forward by the military. However, it will also advance reforming technology promoting civilian use of JP8 and diesel reforming. The prototype will allow future fuel cell powered Aerospace Ground Equipment and other fuel cell technologies, for military and commercial industry, greater access by increasing fuel availability worldwide.

REFERENCES:
1. www.hydrogen.no/Wurster/lecture.htm,

2. http://www.calstart.org/about/pngv/pngv-0305.html

KEYWORDS: JP8, Hydrogen, Reforming

AF02-278 TITLE: Advanced Electric Vehicle Research

TECHNOLOGY AREAS: Ground and Sea Vehicles

OBJECTIVE: Research the feasibility of emerging electric drive technology based on Air Force vehicle fleet needs and operational parameters and demonstrate that new technology can meet these needs.

DESCRIPTION: Perform initial applied research to gain knowledge and understanding with follow on technology demonstration to provide the next step in electric vehicle transportation technology. The focus of the applied research is to gain knowledge on various types of new battery chemistries currently being developed. Combine these new battery types with various new types of power conditioning and power electronics and the potential exists for a new generation of electric drive technology to be created. Currently the Air Force has over 80 S10 electric pickup trucks that will be used as a baseline and platform for the phase II demonstration effort.

PHASE I: Gain knowledge and understand of the new types of electric drive component technologies and using this applied research, develop a systems integration plan that will allow the technology to be demonstrated in phase II. Computer simulations provide significant feasibility and practicality of design and that components are nearly available for manufacturing. Plan should ensure system meets environmental issues, including electromagnetic interference, safety, and possesses a lower life cycle cost than current configurations.

PHASE II: This demonstration phase will showcase the performance parameters discovered during the applied research phase will meet Air Force needs in the commercial vehicle fleets.

PHASE III DUAL USE APPLICATIONS: This technology could provide an almost pollution free source of public transportation for the commercial sector and government use. Since the Army has now said all of its vehicles will be electric drive by 2010 it provided more advanced technology for not just the Air Force but DoD as a whole.

REFERENCES:
http://www.epri.com/

KEYWORDS: Batteries, Electric Drive, Buses, Clean Air, S10 EV

AF02-279 TITLE: 72kw Hydrogen Fuel Genset

TECHNOLOGY AREAS: Ground and Sea Vehicles

OBJECTIVE: Research and develop a mobile Fuel Cell meeting current military –60 power generator configuration and requirements for Joint Strike Fighter/F-22 weapon systems.

DESCRIPTION: Currently the Air Force has a growing need for clean support equipment. This SBIR will conduct applied research into which fuel cell technology can meet that need to power aircraft with 400Hz and 270vDC, similar to our existing –60 and –86 Mobile power generators that are used on flight lines. 72kw should be available to a single or combination output of 100V AC single/three phase 60/400 Hz and or 28/270 V DC. Expand on the commercial leaders methods, for portable energy generation that specifically meets the needs of Air Force and Department of Defense yet is flexible enough for commercial use. This level of loading and transient response profiling has never been accomplished nor attempted from fuel cells before. The physical design must meet or exceed the existing platform for an improved and seamless integration this alone is another large technical barrier that must be addressed.

PHASE I: Conduct applied research into various fuel cell and power conditioning technologies that meet or exceed the current –60 power generator specifications while analyzing the best fuel source considering battlefield availability. The research must consider mobility, safety, and environmental issues.

PHASE II: Develop prototype system to improve design performance, versatility, reliability, and improvements over the current system.

PHASE III DUAL USE APPLICATIONS: Civilian as well as military flightlines use mobile gensets as well as other non-flightline applications where mobile power is required. Current diesel non-road engines are large sources of air pollution and impending regulation from EPA will force both civilian and military to clean up.

REFERENCES:
1. MSGT Robert Wertz, AEF Battlelab, http://www.mountainhome.af.mil/AEFB

KEYWORDS: Genset, Fuel Cell, Hydrogen, Aircraft Power, Mobile Power

AF02-280 TITLE: Aircraft Wiring Inspection System

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop a wire inspection system/technique that can non-intrusively inspect aircraft electrical wire preferrabley without disconnecting the cannon plugs.

DESCRIPTION: Aging Aircraft wire related Mishaps have received a lot of attention since the TWA 800 accident. Methods and techniques must be developed to allow determination of the wiring systems in aircraft structure. Wiring failures are causing mission loss and are a major contributor to mishaps related to electronics. Wiring failures also require extensive diagnostic testing, troubleshooting and repair, which significantly add to Air Force sustainment costs.

PHASE I: Preliminary/conceptual design for the wire inspection system will be developed and its feasibility will be demonstrated. A test of at least one set of critical wiring bundle will be performed to prove the efficacy of the wiring inspection system. Develop a sensory and prognostic system design and methodology that includes sensor specifications and software support for prognosis and diagnosis for wiring the prognostic and diagnostic system must account for fiber performance, connector interface performance, and signal attenuation. The prognostic algorithms must also estimate the time element for future performance degradation. The prognostic/diagnostic system should demonstrate a proof-of-principal prototype incorporating selected sensors. Demonstrate detection and prognosis capability with near location of suspected fault indication, connector or fiber.

PHASE II: Develop diagnostic equipment and procedures necessary to assess the integrity and residual life of the optical wiring. Build an optical test system to demonstrate portable field and or space application inspection capability of the system. The wire inspection concept developed in Phase I will be applied to wiring systems in the actual F-15 aircraft.

PHASE III DUAL USE APPLICATIONS: Aircraft certification, vehicle safety and manufactureer liability concerns are major reasons for utilization of this technology. With the continued aging of both commercial and military fleets, wiring problems will continue to grow. The ability to easily replace metallic wiring systems with optical systems is needed in the aerospace, automotive and construction industries. The diagnostic tools developed under this SBIR wil have widespread use.

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1. Proceedings of the SAE Aircraft Safety Conference, April 1999

2. "Prognostics for Wiring: Managing the Health of Aging Wiring Systems," Third Joint FAA/DOD/NASA Conference on Aging Aircraft, September 1999, with G. Smith, J.B. Schroeder, Air Force Research Lab, R. McMahon Raytheon, K. Blemel, Management Sciences, Inc.

KEYWORDS: Optics, Prognostics, Diagnostics, Sensors, Wavelength Division Multiplexing, Portable/miniaturized

AF02-281 TITLE: Inspection of Subsurface Flaws Around Fasteners on Aircraft

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop an inspection system/technique that can inspect for subsurface flaws around fasteners on the aircraft.

DESCRIPTION: With the many aircraft within the Air Force becoming older there is a need to inspect for cracks and flaws at the origination of these cracks. Presently these cracks are not found until the aircraft has been removed from service and some disassemble done and or during flight some problems occur. These cracks and flaws are causing troubleshooting and repair, which significantly add to Air Force sustainment costs. A major drawback to utilizing current methods of inspection requires the aircraft to be removed from service and disassembled for inspection. This leads into a host of problems. The goal of this SBIR project is to research a method to inspect for these subsurface flaws without removing the skin of the aircraft.

PHASE I: Research and develop a method to detect subsurface cracks in aerospace vehicles. Demonstrate the ability to detect 0.050-inch corner flaws emanating from fastener holes located on the wing of the aircraft. Demonstate concept feasibility. Demonstrate the ability to detect corner flaws between layers 1 and 2, 2 and 3, and 3 and 4 is necessary. Design the prototype system to be built in Phase II.

PHASE II: Develop and demonstrate a portable, easy to use, and cost effective system to be used on the outside of the aircraft. This system should be able to detect the subsurface flaws on the aircraft without removing the skin of the aircraft. Develop and demonstrate the system prototype on a demonstration article representative of the actual C-141/F-15 structure. Review prototype design with AF personnel for robustness, integration with existing practices and ability of AF personnel to have the prototype unit maintained and repaired. Buid the prototype unit. Demonstrate the operability to AF personnel and provide a users/maintenance manual for expected operation.

PHASE III DUAL USE APPLICATIONS: Potential applications include inspection of metallic structures including commercial aircraft, naval vessels, automobiles, and rail systems or building structures. Potential customers include aerospace, nuclear, marine, and automotive concerns, FAA, DoD and the DOE.

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1. ASM Handbook, Nondestructive Evaluation and Quality Control, vol. 17, J.R. Davis, S.R. Lampman, ASM International, 1994, Ultrasonic Testing of Materials, Krautkramer, Krautkramer, Springer Verlag, 1990.

KEYWORDS: Nondestructive inspection, Crack detection, Inspection

AF02-282 TITLE: Inspect Composite Components of the Aircraft

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop an inspection system/technique that can inspect the composite components of the aircraft.

DESCRIPTION: Many types of aircraft components are now made of composite materials. There remains the need to continually inspect critical areas for disbonds and delaminations within the core of the component. These critical areas include everything from speed brakes, rudders, propellers, aeirons, and other airframe components. The disbonds and delaminations can occur for a variety of reasons i.e. bird strikes, mechanics dropping tools or running equipment into the components. Damage to a component allows water to be trapped thus causing extensive diagnostic testing, troubleshooting and repair, which significantly adds to Air Force sustainment cost. A method or instrument is sought with the ability to detect subsurface flaws in composite materials. The instrument should be portable, easy to use, and cost effective.

PHASE I: Research and develop a method to detect damage/flaws in composite components in aerospace vehicles. Demonstrate the ability to detect disbands and delamations within the composite material on an F-15 component.

PHASE II: Develop and demonstrate a portable, easy to use, and cost effective system to be used on the outside of the aircraft. This system should be able to detect the subsurface flaws on the aircraft. Apply the results of Phase I to the design, fabrication, and experimental validation of the prototype unit. Demonstrate the operability to AF personnel and provide a users/maintenance manual for expected operation.

PHASE III DUAL USE APPLICATIONS: Potential applications include inspection of composite structures including commercial aircraft. Potential customers include aerospace, FAA, DoD and the DOE.

REFERENCES:

KEYWORDS: Aging aircraft, NDE, NDI, inspection

AF02-283 TITLE: Sled Vehicle Aerodynamic Load Prediction Capability

TECHNOLOGY AREAS: Ground and Sea Vehicles

OBJECTIVE: Develop a rapid and accurate computation capability to determine aerodynamic forces and heating on test track ground test vehicles.

DESCRIPTION: The Holloman High Speed Test Track (HHSTT) at Holloman Air Force Base, New Mexico, is a ground-based aerospace test facility used for testing various DoD systems including missile guidance, aircraft crew egress, weapons, and countermeasures. Testing is conducted with single-stage and multiple-stage rocket boosters to accelerate test articles to desired speeds. The test speeds range from the subsonic regime of a few hundred feet per second to hypersonic speeds of ten thousand feet per second. For all missions, rocket sled vehicle aerodynamics in proximity to the ground is a major consideration for structural and thermal design. Test Track engineers normally use hand calculations and past experience to make pre-test loads and trajectory performance estimates. However, new test requirements result in the need to reduce design margins to meet higher velocity/payload requirements. To reduce design margins, load estimates need to be more accurate than the current techniques. Currently, when very accurate estimates are needed, Computational Fluid Dynamics (CFD) is used to estimate the aerodynamic conditions. Unfortunately, CFD analyses are often very time-consuming and do not meet customer's schedule requirements. Therefore, the Holloman High Speed Test Track has a need to develop procedures and tools that test engineers can use to accurately and rapidly predict aerodynamic forces acting on test vehicles as well as aerodynamic heating on high speed sleds. For example, the build-up or "stacking" of 3-D geometrical components is one possible procedure for computing aerodynamic and aerothermal loads on any arbitrary sled vehicle. Since the 1970's, NASA/Goddard Sounding Rocket Division has successfully used a concept of building-up or "stacking" of 3D geometrical components with known aerodynamic characteristics to quickly and accurately generate aerodynamic forces on supersonic atmospheric flight vehicles. This concept is implemented in commercial software products such as JA-70, LANMIN, AVID, SHABP, and others developed under funds provided by NASA and the DoD. Unfortunately, these software products do not account for ground plane effects on the aerodynamics. Other concepts for the development of a flexible, accurate, and responsive aerodynamic prediction tool and/or tools to solve these problems could also be developed. Integrating the effects of the Test Track ground plane shock reflection and multiple body interference will be the highest risk area in this effort.

PHASE I: Determine the technical feasibility of a quick and accurate aerodynamic load prediction tool that includes the effects of complex ground planes and multiple bodies. Conceptually design the engineering tool that can be used to generate aerodynamic data for real-world sled vehicles.

PHASE II: Complete the design and development of the aerodynamic prediction software tool. Based on actual sled test data and CFD, validate the prediction accurately models the range of sled test vehicles including: dual rail sleds, monorail sleds, velocities from low subsonic to Mach 10, multiple stages, etc.

PHASE III DUAL USE APPLICATIONS: 1. Any and all military ground vehicles could benefit from this tool. With the tool operational, ground vehicle designers could produce more effective designs and ultimately more efficient vehicles. 2. Automobile Industry: To design safer, more fuel-efficient consumer automobiles by populating the database with tailored or unique performance test data. 3. Railroad Industry: To design faster, more stable passenger and freight rail systems. 4. Commercial Aircraft Industry: To provide a database specifically designed to evaluate new designs during transition from taxi-to flight.

REFERENCES:
1. AIAA 96-0290, Aerodynamic Computation of Integrated Missile-on-Sled Vehicles, S.C. Praharaj and R.P. Roger, AIAA 34th Aerospace Sciences Meeting, Reno, NV, January, 1996.

2. AIAA 2000-2288, Requirements for Upgrading the Holloman High Speed Test Track Computational Fluid Dynamics Analytical Capability, William P. Schoenfeld, 21st AIAA Advanced Measurement and Ground Testing Technology Conference, Denver, CO, June 2000.

KEYWORDS: GROUND VEHICLE DESIGN, GROUND EFFECT AERODYNAMICS, AERODYNAMIC DESIGN TECHNIQUES, HYPERSONIC ROCKET SLEDS,

AF02-284 TITLE: Cellular Telemetry of Flight Test Data

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Conduct a systematic study to gain knowledge and understanding necessary to determine the means and feasibilty of a real-time flight test data acquisition, display and analysis capability for a large quantity of measurement parameters in multiple Inter-Range Instrumentation Group (IRIG) formats that uses low-cost, commercial cellular and satellite telephone technology and systems as an alternative to dedicated ground stations. The techical risk is developing encoded, encrypted and errorless data compression techniques at narrowband telemetry equivalency while addressing the ciritcal requirement for accurate time-tagging using commericial celluar telephony technology.

DESCRIPTION: Telemetry is used to transmit flight test data from aircraft to ground-based stations where it is recorded, analyzed, and displayed in real time. Current systems employ high frequency radio transmission that requires a ground station within line-of-sight to the test aircraft. This traditional method of test uses established range facilities or requires the use of mobile ground stations, both of which have limited geographical coverage and are costly to establish and operate. Further, current systems compete with other commercial and government users for diminishing spectrum bandwidth, which severely limits the number and timing of critical test programs. Cellular and satellite telephone technology has the potential to eliminate dependence on fixed geography ranges and mobile ground stations, there by allowing tests to be performed anywhere access to a cellular network or satellite is available. It has the further potential to substantially lower the cost of obtaining flight test data by leveraging commercial data networks and telecom equipment. Flight test data in standard IRIG formats can be sent to data recording, analysis and display centers by existing cellular or satellite telephone networks or by a dedicated network of low-cost cell sites. Techniques are available for encrypting and compressing the data to overcome bandwidth limitations of telecommunications protocol.

PHASE I: Conduct a systematic study of the compression, transmission (by cellular telephone network), decommutation, and display of telemetry data based on emerging celluar telephony technology. The study will address those critical elements and the basic components of the technologies to meet the operational requirements. Produce an unconstrained plan that will address the approach, technology (available and required), schedule and cost to achieve the requirement objective. The goal of the study is to identify potential data compression techiques and protocols to include visually lossless compression that would provide errorless data transmission equivalency. Maximum anticipated data rates will be identified.

PHASE II: Select the most promising approach to meet the stated objectives and conduct development and integration efforts of hardware for field experiments and test. The results of this effort would be a proof of technology feasibilty and would include an assessment of operability and producibility of a flight test rated data acquisition system that will encode, encrypt and send multiple Pulse Code Modulated (PCM) streams of data. Conduct a proof-of-principal demonstrations of a laboratory system that will recover record and display the data, including parameters mathematically derived using multiple data channels from any stream, in real time. The system will be validated by recorded measurements taken during flight-testing that would be used as source data and compared to the results obtained from conventional telemetry.

PHASE III DUAL USE APPLICATIONS: Numerous applications exist for low-cost, wireless data communications that can be used over a broad geographical area. Spin-on examples include flight-testing of commercial aircraft; vehicle health monitoring for cars, trucks, ships, busses and aircraft; medical monitoring of patients; biological monitoring and tracking of animals; and machinery monitoring and diagnostics from a remote location.

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2. International Telecommunications Union. n.d. Recommendation V.32bis (02/91). N.p.

3. Nelson, Mark, and Jean-Loup Gailly. 1995. The Data Compression Book. N.p.: Henry Holt.

4. Patton, Bruno. 1997. Satellite-based Cellular Communications. New York: McGraw-Hill.5. Sreetharan, M., and Rajiv Kumar. 1996. Cellular Digital Packet Data. N.p.: Artech House.

KEYWORDS: Cellular Digital Packet Data, Cellular Telemetry, Data Acquisition, Flight Test Data, Cell Phone Applications, Cell Phones in Airplanes

AF02-286 TITLE: Electromagnetic Modeling and Simulation (EMMS) Capability

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Determine if system level electromagnetic (EM) analyses of complex aircraft configurations are possible through integration of component level analysis techniques.

DESCRIPTION: Deployment of modern weapons systems on operational aircraft requires an intensive system level engineering analysis of EM effects to assure aircraft/store compatibility and safety of flight. An urgent need currently exists in all system program offices to evaluate weapon system performance in realistic operational environments. In addition, as emphasis on development and deployment of directed energy weapons proliferates, a critical need exists for methods to evaluate operational suitability, safety, and effectiveness (OSS&E) of systems operating in hostile and friendly (fratricide) EM environments. The growing complexity of electronic systems and the resulting increase in susceptibility to EM effects, coupled with the over-crowding of the EM spectrum, dictate a critical need for improved analysis methods for the evaluation of EM effects. Traditionally, EM analysis has relied almost exclusively on extensive and very costly ground-based tests like anechoic chamber testing of complete aircraft/weapon systems that provide only limited insight. The numerous combinations of test parameters required for an overall EM effects analysis make complete testing of complex configurations prohibitively expensive. A computer-based system level simulation and analysis capability could significantly improve the efficiency of ground-based testing and substantially reduce certification time and costs. While component level computational analysis techniques are well developed and well understood, the same is not true for system level analysis. Research is needed to bridge the gap between component level and system (e.g., aircraft) level EM phenomenology understanding. Knowledge gained from this research can then be applied toward the development of high-fidelity system level analysis techniques that can be used to streamline the aircraft-store certification process.

PHASE I: Develop and demonstrate the feasibility of combining component level EM analysis methods to perform accurate system level analysis. Propose a methodology for validating the system level EM analysis.

PHASE II: Develop and demonstrate a prototype EMMS computer program in a geometrically complex system environment. Conduct testing to prove feasibility of EMMS system level analysis.

PHASE III DUAL USE APPLICATIONS: In addition to Air Force and other service applications, any organization concerned with EM effects in EM rich environments will benefit from the EMMS concept. Commercial manufacturers can use EMMS technology to design and evaluate electronic suites to minimize mutual interference between various electronics components. EMMS technology will allow commercial manufacturers the ability to evaluate EM compatibility with realistic external EM environments.

REFERENCES:

1. Advances in Computational Electrodynamics: The Finite-Difference Time-Domain Method, Allen Taflove, Artech House, 1998.

2. The Finite Element Method in Electromagnetics, Jianming Jin, John Wiley and Sons, Inc., 1993.

3. Computational Electromagnetics, ed. E.K.Miller, L. Medgyesi-Mitschang, E.H. Newman, IEEE Press, 1992.

4. Computational Methods for Electromagnetics and Microwaves, Richard C. Booton, Jr., John Wiley & Sons, Inc, 1992.

5. Computational Methods of Electromagnetic Scattering, Andrew F. Peterson, Scott L. Ray, and Raj Mittra, IEEE Press, 1998.

KEYWORDS: Electromagnetic; Electromagnetic Fields; Electromagnetic Pulse; EMP; Electromagnetic Interference; EMI

AF02-287 TITLE: Hybrid Computational Fluid Dynamics (CFD) Analysis System for Rapid Assessment of Store Separation

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Determine if a structured/unstructured (hybrid) CFD analysis system can provide rapid assessment of store separation.

DESCRIPTION: Certification of new weapon systems and new weapon combinations (configurations) on operational aircraft requires intensive engineering analysis of store separation behavior to ascertain operational limits to maintain safety of flight. The acquisition of high-fidelity aerodynamic data plays a critical role in this analysis process. Traditionally, wind tunnel data have provided the bulk of the data used in store separation analysis. Unfortunately, the acquisition of new wind-tunnel data generally requires long lead times and incurs significant costs. Methods are sought that can augment and possibly supplant wind tunnel data by providing high-fidelity aerodynamic data and analysis on a significantly shorter time schedule. A CFD based store separation analysis computer program (BEGGAR) exist that meets the basic requirements. While BEGGAR has proven effective in accurately predicting store separation trajectories from aircraft, it is still a very labor-intensive and time-consuming process to build and assemble the three-dimensional structured grids upon which aerodynamic flow solutions are computed. While structured grids, offer advantages in solution and memory usage efficiency, they are ill suited for automated adaptation to aerodynamic flow features such as shocks and vortices and are difficult to construct around the complex surface geometry associated with some modern air-delivered weapons. Unstructured grids offer advantages such as adaptive mesh refinement and simplified grid construction around complex shapes, but they require more memory and are generally less efficient from a flow solution standpoint. With these concepts in mind, an innovative methodology is sought to combine the advantages of both types of grids/flow solvers into a single program for rapid assessment of store separation characteristics from combat aircraft. This methodology should allow the assembly of unstructured and structured grids into a hybrid assembly using automated chimera functions/structures, provide a means to compute Navier-Stokes and Euler CFD solutions on the complete hybrid grid assembly, and account for time-accurate independent motion of grids (necessary for store motion relative to the parent aircraft). Ideally, the methodology will use object-oriented design and programming techniques (modular design) for code re-use in other applications.

PHASE I: Investigate the feasibility of combining a chimera type of structured CFD algorithm with an unstructured CFD program to form a hybrid chimera-CFD program. Provide an assessment of the improvement (if any) over existing methods for performing store separation analysis. Improvements should address reducing grid generation time, reducing grid assembly time, and adding solution adaptation capability. Identify and evaluate suitable algorithms that could become components in a hybrid CFD store separation analysis program. If a hybrid chimera-CFD program is feasible, a preliminary design should be developed. The design should consider best methods for exchanging data between structured and unstructured grids, including methods for exchanging turbulence model data. Modularity should be emphasized. The end-product shall be a detailed report, and the report should include end-user requirements, a conceptual methodology, and a design for assembling unstructured grids with structured grids for the purpose of store separation simulation.

PHASE II: Evaluate the Phase I preliminary design and modify as required. The design will include parallelization and must be modular to facilitate independent development and revision of the parent codes from which the hybrid system is derived. Develop and deliver a prototype hybrid CFD store separation analysis system based on the revised design. Perform verification of the design by computing store separation trajectories and comparing with benchmark cases. Provide an assessment of the improvement over the existing CFD methodology by comparing grid generation and assembly time of the new approach with the previous, structured-grid-only approach. Identify areas for potential improvement and propose design improvements.

PHASE III DUAL USE APPLICATIONS: A modular design will allow other chimera CFD developers to rapidly integrate the unstructured features (module) into their applications. Military and commercial applications include helicopter rotor aerodynamics simulation, rocket booster separation analysis, multi-element wing design, and many other simulations involving bodies in relative motion in complex flow fields.

REFERENCES:
1. Jolly, B. A., and M. Rizk. 1999. A Newton-relaxation Finite Volume Scheme for Simulation of Dynamic Motion. In Finite Volumes for Complex Applications II Problems and Perspectives, ed. R. Vilsmeier, F. Benkhaldoun, and D. Hanel. 2nd Annual International Symposium on Finite Volumes for Complex Applications Problems and Perspectives, 19-22 July, Duisburg, Germany. Paris: Hermes.

KEYWORDS: CFD, Fluid Dynamics, chimera, unstructured grids, object-oriented programming (OOP), multidisciplinary design, parallel programming

AF02-288 TITLE: Global Positioning System (GPS) Simulator Phase Calibration

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop and demonstrate an automated integrated GPS Radio Frequency (RF) phase calibration method to interface directly with existing GPS satellite constellation simulators. Measure the relative phase delays that exist between RF outputs for multiple simulated satellite channels, and calibrate the simulator to compensate for these delays.

DESCRIPTION: GPS Real-Time Kinematic (RTK) techniques utilize the RF characteristics as transmitted from the satellites to compute very accurate vehicle position data. To simulate this environment, an identical carrier frequency has to be generated for each satellite across multiple RF outputs. Because of the architecture, firmware, etc. of existing satellite constellation simulators, the simulated carrier frequencies for each GPS satellite (simulator channel) are not in phase across multiple RF outputs, thus producing a signal delay that does not exist in the "real world". This limits submeter rather than millimeter position accuracy when RTK techniques are used. The need exists for a system capable of interfacing with the RF outputs of existing GPS simulators and measuring the phase delay for both L1 and L2 GPS frequencies across all the simulator channels. This must be accomplished at an operational power level of approximately -163dBw. Currently, no equipment exists to measure and calibrate per satellite GPS RF signals, which are well below the RF noise level.

PHASE I: Research the feasibility of developing technology capable of meeting the technical description specified, which has the potential to calibrate any GPS simulator.

PHASE II: Design a prototype system and demonstrate proof-of-concept capability.

PHASE III DUAL USE APPLICATIONS: Military application of this technology would be for the modeling and simulation of RTK scoring of GPS guided weapons using carrier phase differential techniques such as advanced missile instrumentation and Enhanced Time-Space-Position Information (E-TSPI). Applications in the civilian world might include modeling and simulation of GPS guidance systems in commercial aircraft, future improvements in automobile technology, and/or snowplow guidance where carrier phase differential technology would produce significant improvements to GPS code techniques.

REFERENCES:
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KEYWORDS: Real Time Kinematic, GPS satellite constellation simulator, modeling and simulation, GPS guided weapons, GPS carrier frequencies, carrier phase differential techniques.

AF02-291 TITLE: High Performance Real-Time Synchronization Clock

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Technological feasibility of a high performance real-time synchronization clock for Hardware-In-The-Loop Testing.

DESCRIPTION: Hardware-In-The-Loop (HITL) testing is the laboratory testing of a hardware system by stimulating the system inputs, capturing the system outputs, and modeling the physical environment. An example of this would be evaluating the performance of a missile guidance system. Computer simulation models would provide feedback to the system to "fool" it into thinking it is in operational flight. But in order to successfully fool the system, the computer models must provide feedback at a rate that the system would encounter in the real world. This is where a real-time clock comes in. A real-time clock provides a reference for the computer models to use in communicating with the system. Considering that a typical HITL system needs to be updated about 2,000 times per second with very low latency, it is easy to show how the accuracy of a real-time clock could directly affect the ability to "fool" the system. Equally important is the ability to maintain time synchronization with an absolute time source such as Global Positioning System (GPS) or Inter-Range Instrumentation Group (IRIG). Currently, the best resolution from a commercial off-the-shelf (COTS) real-time clock is 50 nanoseconds. The resolution is the time in between clock ticks. Current COTS real-time clocks are barely meeting present requirements and, to meet the future needs, a clock with resolutions in the range of 10 to 20 nanoseconds is expected. Future real-time clock systems should provide for a drift rate of less than 1 millisecond over a 24 hour period with latency of less than 2 microseconds. Any clock system which

meets AF needs will utilize a PCI Local Bus Controller bus interface. Of course the clock would have to include a number of programmable features allowing a user to set timer intervals (50-300 microseconds), timer increments (10-20 nanosecond increments, and timer pulse width (100 nanoseconds to 4 milliseconds) along with the ability to set pulse polarity at either positive or negative."

PHASE I: Investigate high-payoff approaches for the development of next generation real-time synchronization clocks. Perform design analysis through modeling and simulation. Develop initial concept design and demonstrate feasibility through a breadboard demonstration device.

PHASE II: Finalize the initial designs developed in Phase I. Develop software drivers for multiple operating systems, to include DOS, OpenVMS, Linux, QNX, and WindowsNT, to ensure adaptability. Based on final design, develop and test pre-production prototype system which includes software drivers.

PHASE III DUAL USE APPLICATIONS: Military applications would include: DoD HTIL Testing Facilities. Commercial applications would include: HTIL Testing Facilities, Real-time Industrial Control, and Applications requiring low-latency precision timing.

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1. Gary Taubes, The Global Positioning System - The Role of Atomic Clocks, Beyond Discovery: The Path From Discovery To Research, National Academy Of sciences, (1997).

2. MicroMentor, Understanding and Applying MicroProgrammable Controllers, Allen-Bradley Company, Inc., (1995).

KEYWORDS: Modeling & Simulation, Real-time, Hardware-In-The-Loop, High performance Timing, Real-time Clock

AF02-292 TITLE: Ultra High Speed Framing Pulsed X-ray System

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop an ultra high speed framing x-ray system for viewing ballistic impacts.

DESCRIPTION: Current X-ray imaging systems used in the ballistic range area are single pulsed one image per film plane systems. There is need for an ultra high speed framing x-ray system to view multiple images from one location. The requirement for this system is to produce multiple x-ray images on a single digital large format screen that can be captured and stored electronically at the rate of 1 megahertz. The large format screen (approximately 36 inches square) could be a compilation of smaller screens but they must be integrated to produce one continuous image. The refresh rate of the imaging screen should not exceed 1 microsecond and the storage medium should accommodate at least a 100 frames. The imaging screen will be located in a shrapnel prone impact area and should be either low cost (disposable) or have an alternate method of preventing damage to high cost components. The X-ray system should have adequate resolution to image small particles (1/8 inch aluminum) and should have a power level of 150kv or higher.

PHASE I: Demonstrate the critical aspects of the proposed system. The system should capture and store at least two images at the 0.5 megahertz rate with adequate resolution. The two images can be from two x-ray sources but should be imaged on a single screen and stored electronically.

PHASE II: Develop and demonstrate the prototype system as described in the topic description.

PHASE III DUAL USE APPLICATIONS: A high speed framing X-ray device would have multiple uses in numerous ground test facilities, government labs, and commercial testing organizations where the velocity of high speed particles must be tracked in harsh environments. In addition a system such as this would be useful in the medical industry for motion diagnostics of joints. A portable system of this type might also be useful for the health monitoring of industrial equipment during operation.

REFERENCES:
1. X-ray Phosphors and Screens; ASTM stp-716,J.D. Kingsley,AD#ADD311763.

2. Catoptrical X-ray Optical System;AFOSR-78-3480; James F. McGee; AD#ADA084688.

3. Tunable, Short Pulse Hard X-Rays from a Compact Laser Synchrotron Source; NRL/MR/4790-92-6973; Philip Sprangle, Antonio Ting, Eric Esarey, Amnon Fisher, AD# ADA254288

KEYWORDS: Ultra High Speed Framing, X-ray, Digital Screen, Electronic Storage

AF02-293 TITLE: Exhaust Gas Trace Species Detection System for Turbine Engines

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop the ability to detect component wear through the detection of very low concentrations of their material emissions signature in the engine exhaust stream.

DESCRIPTION: The ability to detect elements of these engine components in very low concentrations in the exhaust stream would enable the early detection of component failure. For example, if a seal fails catastrophically, then aluminum seal fragments may impinge on vanes and blades, which has the resultant effects of blocking component cooling passages and alloying of the aluminum with the vane or blade material resulting in a severe degradation of the blade or vane material strength. After an hour or so of this alloying process, the component will need to be scrapped. This represents a very expensive consequence. The signature for blade or vane failure would be one of the metals of the component's alloy such as nickel since this element is the principal constituent of high temperature nickel alloys. The technology makes use of atomic emission spectroscopy. It uses a novel method to generate robust and large volume atmospheric air plasma that can handle high flow loading and excite the elements. A specially designed high-sensitivity spectrometer is used to detect the light emissions. At any given moment, the spectrometer has the ability to extract very low signals from a high background. A gas sample is continuously drawn from the jet engine exhaust and injected through the microwave-generated plasma. The hot plasma volatilizes any particulate in the gas stream and excites the atomic species that emit light at specific wavelength. Parts per billion (ppb) detection levels have been achieved in the laboratory for metals such as mercury, chromium and lead.

PHASE I: Develop and demonstrate a Trace Species Detection System for turbine engine health monitoring system in the laboratory. The Phase I demonstration can be extractive (probe based) or totally non-intrusive (optically based).

PHASE II: Develop and demonstrate a turbine engine health monitoring system based on the detection of species from component wear in the turbine engine exhaust plume.

PHASE III DUAL USE APPLICATIONS: Both military and commercial applications exist for this system. Turbine engine developers have expressed an interest in a system capable of detecting component wear or the precursors to component failure during development testing. Both the military and commercial aircraft communities are searching for engine diagnostic / prognostic capabilities to help them better schedule maintenance.

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2. "OPAD Data Analysis", T.L. Wallace (Svt), W.L. Buntine (NASA), AIAA 29th Joint Propulsion Conference, June 28-30,1993, Monterey, CA..

3. "Space Shuttle Main Engine Plume Diagnostics: OPAD Approach to Vehicle Health Monitoring, " T.L. Wallace et al, SAE Aerotech '93, September 28-30, 1993, Costa Mesa, CA.

KEYWORDS: Turbine Engine Health Monitoring, Exhaust Plume Diagnostics, Trace Species Detection

AF02-294 TITLE: Determination of Airframe and Weapons Bay Acoustic Signature in High Subsonic Speed Wind Tunnel Tests

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a method/means to accurately determine and characterize acoustic sources in a wind tunnel.

DESCRIPTION: Accurate determination of the acoustic signature (airframe noise and weapons bay acoustics) generated by test articles in a wind tunnel at high subsonic speeds is of high importance to many applications. In-flow phased microphone arrays have been used with success in low speed tunnels with solid walls to determine airframe noise. Critical to the success of the in-flow approach is the accounting for the effects of the boundary layer noise contaminating the measurement. Transonic wind tunnels are more complicated since the porous walls of the tunnel

generate a noise signature that is of the order of three to four times that of the boundary layer noise. Other noise sources such as compressor blade passing noise and jet interactions in the diffuser also generate significant disturbances in the spectra. For weapons bay acoustics measurements, the background noise can mask the noise generated by shear layer interacting with the cavity. The shear layer distorts transmission of sound through the shear layer. Consequently, the accurate determination of aerodynamic noise from the test article requires a phased array system that can provide an accurate assessment of all external noise sources and a means for correcting for transmission losses caused by both shear and boundary layer interactions. Development of such a phased array system and appropriate validated computational fluid dynamics augmentation is anticipated.

PHASE I: Develop and demonstrate a phased array system suitable for a wind tunnel. Provide supporting analytical/empirical measurement correction methodology for acoustic measurements in wind tunnels.

PHASE II: Develop and validate a phased array system that has empirical methodology for correcting for effects of shear & boundary layers and can extrapolate the Reynolds number effects to flight conditions.

PHASE III DUAL USE APPLICATIONS: The potential for application to other wind high subsonic wind tunnels within the United States is high. A portable phase array system would find application to noise source location in manufacturing processes (eg. bearing failure).

REFERENCES:
1. A.Vakili, and Springer,R" Acoustics Measurements and Prediction technique in Wind Tunnels" AIAA Paper No.99-2170, Joint Propulsion Los Angeles, CA 1991)

2. "Acoustic Measurements and Background Noise Separation in Wind Tunnels", Sekhar Radhakrishnan and Ahmad D. Vakili, AIAA paper 99-1990, Proceedings of the 5th AIAA/CEAS Aeroacoustic Conference. 1999.

3. "Review of Acoustic Measurement Techniques in Wind Tunnels (Invited)", A.D. Vakili, and S. Radhakrishnan, 21st AIAA Advanced Measurement Technology and Ground Testing Conference, June 2000.

KEYWORDS: acoustics, noise, weapons bay acoustics

AF02-295 TITLE: Integrated Visible/IR Calibration Source

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop an integrated dual band radiation source for sensor calibration and testing.

DESCRIPTION: A means of combining blackbody radiation (2 to 12 μm) and continuous visible radiation (0.5 to 1.0 μm) in an efficient manner is needed so that both wavebands can be presented from the same optical port. Standard integrating sphere coatings have poor efficiency at either the visible end of the spectrum or the infrared. The challenge is to find a high efficiency source over a wide range of spectral content at 2500 Deg F. An innovative technique is desired that can integrate the disparate visible and long wavelength infrared sources producing the two wavebands simultaneously so that minimal losses (< 10%) to each are incurred. The character of the infrared spectrum must be preserved as much as possible. Preservation of the visible spectrum is also desired, but is secondary in importance. The technical risk for achieving this level of throughput is high.

PHASE I: Develop and demonstrate the feasibility of providing high power infrared and visible radiation from the same orifice.

PHASE II: Develop a practical prototype, which is capable of producing high power infrared (2 to 12 μm) and visible radiation (0.5 to 1.0 μm) from the same orifice.

PHASE III DUAL USE APPLICATIONS: This technology will be useful for a variety of sensor test activities where a dual band (visible and IR) source is needed for calibration and dynamic simulation. As surveillance and process control moves toward dual wavelength sensing development facilities can benefit from such a calibration source.

REFERENCES:
1. Havstad, M.A., et.al., "A Radiation Source for both the visible and the infrared," Infrared Physics, 34, 2, pp. 169-174, 1993.

2. Nicholson, R.A., and Mead, K.D., "Complete Characterization of Advanced Focal Plane Arrays at the Arnold Engineering Development Center", SPIE 3379, p. 12ff.

3. Nicholson, R.A., and Steele, C.L., "AEDC Focal Plane Array Test Capability", AEDC-TR-90-31.

KEYWORDS: sensor, infrared, IR, radiation source, visible, radiometric calibration

AF02-296 TITLE: Non-Intrusive Flow Visualization Diagnostic System for Aircraft Flow Fields

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop a non-intrusive, cost-effective wind tunnel technique for measuring aircraft flow field properties.

DESCRIPTION: Characterization of the time-dependent, three-dimensional flow fields associated with wind tunnel aircraft and missile models is often required during testing for system performance estimation, electromagnetic and aerodynamic field interaction, and towed decoy dynamics studies. The current techniques are limited to more-or-less qualitative flow field characterization using laser vapor-screen, shadowgraph, and Schlieren techniques.

PHASE I: Research and demonstrate technical feasibility to characterize the time dependent three dimensional flow field in the laboratory.

PHASE II: Develop, demonstrate a non-intrusive flowfield characterization system (hardware, software, methodology) for use in a wind tunnel environment. Demonstrate the ability to quantitatively relate flowfield properties, including unsteadiness, to sensor measurements for time-dependent, three-dimensional flowfields behind wind tunnel models. High accuracy is desired. Allowable two standard deviation error at 95% confidence interval between sensor and non-intrusive results is 0.4% of full-scale sensor range.

PHASE III DUAL USE APPLICATIONS: In addition to high subsonic speed wind tunnel application, a cost-effective, efficient remote sensor system would have applications in chemical continuous process control. Additional applications of the technology include automotive aerodynamic flow characterization in both wind tunnel and outdoor track environments, wind hazard studies and analyses in dense-structure environments, aircraft trailing flow-field hazard analyses, and characterization of industrial airflow systems.

REFERENCES:
1. Balser, M., et al., "Acoustic Analysis of Aircraft Vortex Characteristics," Federal Aviation Administration, FAA-RD-72-81, Xonics Corp., Van Nuys, CA, July 1972.

2. Chadwick, R. B., et al., "Radar Detection of Wingtip Vortices," Reprint Volume of Extended Abstracts: Ninth Conference on Aerospace and Aeronautical Meteorology, Boston, MA, June 1983.

3. Bilbro, J. W., "Laser Doppler Velocimeter Wake Vortex tests," Federal Aviation Administration, FAA-RD-76-11, NASA/MSFC, Huntsville, AL, March 1976.

KEYWORDS: Visualization Non-Intrusive Flowfield

AF02-297 TITLE: Vortex Flow Detector for Turbine Engine Test Facilities

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a flow-field monitoring system that may be used to detect the development of bellmouth vortices in direct-connect turbine engine test facilities.

DESCRIPTION: Direct-connect turbine engine tests often use a bellmouth as the transition between the facility plenum chamber and the engine air supply duct. This bellmouth may be used to determine the airflow rate supplied to the engine to accuracies as low as 0.5%. The engine airflow rate is a critical measurement for the determination of engine performance parameters such as thrust and fuel consumption. Measuring airflow using the bellmouth requires suitable measurements of pressures, temperatures, and throat area as well as knowledge of the bellmouth flow coefficient. However, flow anomalies in the bellmouth flow, most notably vortices, may cause significant errors in the airflow inferred from the bellmouth measurements. Bellmouth inlet induced vortices have been previously observed in

ground test facilities, and design modifications have been adopted to prevent their formation. However, the effectiveness of each test installation with respect to flow quality must be ensured. Therefore, a system that monitors the inlet flow field and senses the presence of vortical flow, from whatever source is needed to alert the test team in the event that unacceptable conditions develop. The system must provide near-real time results and must be passive in the sense that it must operate during and without interference to test operations and without requiring manual operations or user intervention.

PHASE I: Research and demonstrate technical feasibility of the selected method.

PHASE II: Develop and demonstrate the prototype vortex monitoring system in a turbine engine test facility utilizing bellmouth flow measurement system.

PHASE III DUAL USE APPLICATIONS: Autonomous flow monitoring system that may be used to monitor flow quality in aerospace ground test facilities and industrial plants.

REFERENCES:
1. Beale, D. K. "Improving Information Productivity and Quality in Turbine Engine Ground Testing." AIAA Paper No. 2001-0163

2. De Siervi F., Viguier, H. C., Greitzer, E. M. and Tan, C.

S. "Mechanisms of Inlet-Vortex Formation," Journal of Fluid Mechanics, Vol. 124, 1982, pp 173-207

3. Reed, J. A., Hiers, R. S., Jr. and Turrentine, W. A. "Improvement of Flow Quality in Turbine Engine Test Cells by the Elimination of Bellmouth-Unduced Core-Flow Vortices," AIAA Paper No. 95-2391

4. Bissinger, N. C. and Braun G. W. "On the Inlet Vortex System." NASA CR-132536, 1974

5. Motycka, D. L., Walter, W. A., and Muller G. L. "An Analytical and Experimental Study of Inlet Ground Vortices." AIAA Paper No. 73-1313.

KEYWORDS: Bellmouth Vortex

AF02-298 TITLE: Microsensors for Gaseous Emissions Analysis

TECHNOLOGY AREAS: Chemical/Biological Defense

OBJECTIVE: Develop species-specific sensors for monitoring turbine exhaust in-situ (in the exhaust stream).

DESCRIPTION: Current gas analysis instrumentation used to detect or measure engine emissions are costly and intrusive. They are also inadequate for use as controls sensors. Recent advances in MEMS technology suggests that microsensors are capable of measuring exhaust gases in the high temperature exhaust environment. A need exists for real-time measurement of the following chemical species: CO, CO2, SOX, NOX, O2, and total hydrocarbons. Microsensors offer a new technology approach that would add controls capability and significantly reduce emissions measurement costs. The availability of point contact chemical sensors will allow real-time determination of spatial and temporal distributions of emissions gases and catalyze the development of more efficient gas turbine and auto engines. Standard emissions instrumentation sensor specifications for turbine engines can be found the SAE Aerospace Recommended Practice 1256B, available from the SAE. These specifications are very similar to the specifications for automobile and stationary source power generation industry. Controls sensors may require higher frequency response. No specifications exists for the turbine engine controls instrumentation so I suggest the submitter design to auto industry emissions control sensor specifications.

PHASE I: Develop and demonstrate a microsensor packaged for the analysis of one or more chemical gas species in a turbine engine exhaust flow.

PHASE II: Demonstrate a chemical gas analysis system based on microsensors packaged for operation in harsh environments capable of replacing a standard gas sampling and emissions measurement system.

PHASE III DUAL USE APPLICATIONS: Development of single chip microsensors with chemical sensing capability and associated signal conditioning, will provide real-time monitoring of gas turbine, combustion ignition, and spark ignition exhaust gases.

REFERENCES:
1. Chemical Gas Sensors for Aeronautics and Space Applications III, G.W. Hunter et al, NASA / TM - 1999-209450, October 1999.

KEYWORDS: Microsensors , MEMS, Chemical Gas Sensors, Aircraft Emissions, Auto Emissions, Stationary Source Power Generation.

AF02-301 TITLE: Subminiature GPS Instrumentation (SGI)

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Research and develop a subminiature instrumentation package combining state-of-the-art GPS/Inertial Navigation System for Time Space Position Information (TSPI) use.

DESCRIPTION: Tightly coupled GPS/Inertial Measurement Unit (IMU) receiver technology has proven to be an effective tool for determining time space position information (TSPI) for aircraft. However, GPS TSPI data is not readily available for platforms with extreme space and weight constraints. Current methods for collecting TSPI for these objects are to treat them as non-cooperative targets and track them with radar or optical ground systems. Radar TSPI data is time consuming to process, and does not satisfy accuracy requirements of most current test platforms and weapons systems. Optical systems produce excellent accuracy using multi-lateration (multiple stations), but the process is extremely labor intense, costly in terms of equipment required, data turn-around time is very slow, and the system is not available in reduced visibility situations. Current industry trends in GPS/IMU technology trade size and cost for accuracy. The smaller and cheaper the unit is, the less accurate the system will become. The capability to instrument an object to self-track and report its position to ground stations would be a valuable asset to the test community. This capability could be achieved by an instrumentation package consisting of a tightly coupled GPS receiver, and an IMU. The end state objectives for this effort are: to develop a GPS/IMU package that is no larger then four cubic inches, the unit must be capable of performing in a high dynamic platform (20G's), the GPS receiver must be capable of providing carrier phase measurements for Kinematic processing, maintain lock though maneuvers greater than 10G's, update rates of 20 Hz, provide compatibility with other IMU systems, and the eventual production instrumentation package should not exceed $3000 per package when purchased in quantity (50 or more units).

PHASE I: Research a proposed instrument to achieve the goals of the project, including feasibility analysis and cost analysis.

PHASE II: Develop a proposed instrument to achieve the goals of the project.

PHASE III DUAL USE APPLICATIONS: The end product of this SBIR is a miniature, highly accurate navigation device that is more reliable then the current GPS solution. This device will have a wide area of application in both the government and commercial sector. Some of its possible uses include autonomous vehicle navigation for cars, trucks and tractors, tracking of payloads, pallets and small private aircraft navigation.

REFERENCES:
1. J. M. Cullen, and Ed. Keller, "Subminiature Telemetry for Multiple Munitions (Technology Transition)", Proceeding of the 1995 International Telemetry Conference, Volume XXXI, 58-65, Las Vegas, NV, 30 Oct - 2 Nov 95.

2. William R. Thursby, Jr., and Benjamin M. Shirley, "Low Cost Subminiature Telemetry Spread Spectrum Technology Demonstration/Validation", Proceeding of the 1995 International Telemetry Conference, Volume XXXI, 74-78, Las Vegas, NV, 30 Oct - 2 Nov 95.

KEYWORDS: subminiature GPS receiver, subminiature inertial measurement unit

AF02-302 TITLE: Wireless Solutions for Time Space Position Information (TSPI) Data Links

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Research and develop an advanced Time Space Position Information (TSPI) data link using commercial wireless standards and technology.

DESCRIPTION: The DoD and other U.S. Government agencies have a severe need for more efficient utilization of the spectrum for range Time Space Position Information (TSPI). The allocated test spectrum continues to shrink while bandwidth requirements are expanding due to increased requirements for accuracy on high dynamic vehicles that have increasingly complex internal systems. Shorter schedules and cost constraints for testing programs are also encouraging the use of real-time data processing rather than post-mission processing. In addition, some test programs rely on real-time TSPI for flight safety information. Another change in the range testing of high dynamic systems is the shift towards network connectivity. The use of networking for TSPI and telemetry data is expected to cause significant increases in productivity and cost effectiveness in flight research as it has and will in other industries. However, wireless networks have significant technical difficulties because of the lack of available bandwidth and the inherent noise, interference and non-uniformity of wireless links. If networked systems are to be used in an environment of combined TSPI and other real-time communication systems with bandwidth at such a premium, efficient use of spectrum will be critical in all layers of the communication stack. The proposed system must allow for at least 20 simultaneous users with varying data rates and ranges. Data rates should accommodate up to 3 Mbps and operate at ranges up to 140 nautical miles. Dynamic assignment and reassignment of operating frequencies and various Multiple Access schemes should be explored. The TSPI data link must be robust, offering data quality bit error rates of 1x10-6 or better and must be capable of operating in harsh environments with multi-path and adjacent channel interference. TSPI data link power cannot exceed 80 watts and antennas cannot interfere with aircraft performance. TSPI data links must not cause interference to other airborne data links. The design should include a description of recommended network- and transport-layer protocols. The goals of this unit is a size not to exceed 3"X4"X4" with a cost not to exceed $10,000.

PHASE I: Conduct a feasibility analysis and prepare a recommended system design.

PHASE II: Develop and demonstrate a prototype system.

PHASE III DUAL USE APPLICATIONS: Numerous applications are easily envisioned. High data rate users with long-range requirements would benefit from this capability. The operational suitability of future field deployable Phase III systems will be inferred from the Phase II results.

REFERENCES:
1. "Time Space-Position Information (TSPI) Multimedia Course", Defense Test and Evaluation Professional Institute (DTEPI), (most current edition)

KEYWORDS: Commercial Wireless, Aeronautical Telemetry, Multiple Access, Variable Data Rates, Telemetry Networks

AF02-303 TITLE: Improved Aeronautical Global Positioning System (GPS) Antenna Systems

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Research and develop GPS antenna systems for aeronautical use, which are capable of operating properly in the presence of strong Radio Frequency fields from nearby Telemetry and Data Link antenna systems.

DESCRIPTION: GPS systems have become an important part of testing aircraft, missiles and other airborne systems at DoD Test Ranges. These systems are sometimes installed on test vehicles in order to obtain high accuracy Time Space Position Information (TSPI) data from high dynamic test vehicles. Additionally, many aircraft are now built with production GPS systems as part of an integrated GPS Inertial Navigation System (INS). The potential for other aeronautical communication systems to interfere with the weak GPS signals becomes higher every time a new system is installed on the test vehicle. There is a need to improve the Radio Frequency Interference performance of GPS antenna systems used on test aircraft at Edwards AFB. The primary objective is to develop GPS antenna systems that will function properly in the presence of strong RF signals from telemetry and/or data-link antennas located near them on the vehicle. Many telemetry and data link systems operate in L-Band, on frequencies close to the GPS L1 and L2 frequencies, so the interference potential is high. There is also signal interference generated from these telemetry and data-link systems that interferes with adjacent transmissions. These spurious signals also cause problems that could be

addressed using anti-jam type GPS antenna systems. Also, due to the limited amount of space available on test aircraft fuselages, it would be beneficial to develop a dual use integrated GPS receiver and telemetry/data-link transmitter antenna system. This would allow simultaneous operation while saving weight and space on board test vehicles.

PHASE I: Conduct a feasibility analysis and prepare a prototype system design.

PHASE II: Develop and demonstrate a prototype system. The prototype will be evaluated to determine if it operates properly in close proximity (> 4") of L-band telemetry transmitter antennas.

PHASE III DUAL USE APPLICATIONS: The commercial aviation industry may benefit from this, if the appropriate system can be developed. The operational suitability of future field deployable Phase III systems will be inferred from the Phase II results.

REFERENCES:

1. "Interoperability of L-band Telemetry Systems with GPS Receivers Aboard Military Flight Test Aircraft", Johns Hopkins University Applied Physics Laboratory, Daniel G. Jablonski, ARTM Program, 7 June 2000.

KEYWORDS: GPS Antenna System, Time Space Position Information (TSPI), Inertial Navigation Systems (INS), Radio Frequency Interference (RFI)

AF02-304 TITLE: High Power, Miniature Infrared (IR) Sources

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Research and develop small programmable Infrared (IR) sources with outputs that are controllable, calibrated, and can achieve high Jammer-to-Signal (J/S) ratios.

DESCRIPTION: The goal is to develop an IR source that increases the simulations J/S ratio output. Wires that allow horizontal and vertical source motion will suspend the IR source. The IR source is to have an iris and associated motor for control of IR intensity. A cooling fan will be placed in the IR source housing to reduce the heating caused by the IR source. The IR source can be any source whose irradiance is equal to or greater than the output produced by a one-inch xenon arc lamp at wavelengths between 1.5 and 5.5 microns. The calibrated J/S ratio should be at a level of at least 100 or more for at least 10 seconds for a specific waveform. After 10 seconds there will be a 35-second down time before being turned on again for the next 10 second up time. This cycle time will continue through an average eight-hour workday. The line length of the power lines will be 50 feet and move with the source over pulleys, necessitating flexible lines.The units should fit in a 2 3/8" diameter by 9" length. Proper cooling (<30 C external housing) and intensity control (0 - 100%) must be achievable. The source must have the capability of being square wave modulated to frequencies of 5000Hz and have a flat (90 - 100%) angular distribution of irradiance over ± 5 degrees. This is needed to maintain calibration as the sources move in the IR foreground. Power enters from the top of the housing and is in line with the mounting wires on the top of the housing.

PHASE I: Research and develop a proposed system design and make recommendations on the construction of the system using multiple sources. Submit a report covering the research approach, design and results.

PHASE II: Prototype, integrate, and demonstrate a working system. Submit a final report documenting the intensity range, control repeatability, and positioning accuracy and speed.

PHASE III DUAL USE APPLICATIONS: This will be a new product that has potential use in (1) IR countermeasure needing closely placed sources; (2) Aircraft landing lights; (3) IR communication (Land, sea, air, and space); (4) Satellites IR sources; (5) Portable IR sources.

REFERENCES:

1. "The International Countermeasures Handbook", Englewood, CO, Cardiff Publishing, (most current edition).

2. "The Infrared Handbook", The Infrared Information Analysis (IRIA) Center, Environmental Research Institute of Michigan, (most current edition).

KEYWORDS: Infrared, Calibration, Optical, Real-time, Missile, Infrared, IR target, Optical, Real-time, Missile countermeasures, Xenon arc lamps

AF02-305 TITLE: Clutter Model Based on Real-Time Terrain

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Research and develop a realistic clutter model for airborne radar based on a real-time terrain database.

DESCRIPTION: One aspect of an Installed System Test Facility (ISTF) is the testing of aircraft avionics and the airborne radar providing the avionics data. Ground testing requires presenting the test radar with an accurate representation of the radio frequency (RF) environment as would be seen in flight.Modern radar needs to minimize the effects of clutter and to increase the probability of correctly locating and tracking targets in the real world clutter environment. These radar measurement techniques use the return signal amplitude, Doppler shift, angle of arrival (azimuth and elevation), and time variations in these parameters to help improve the probability of correctly detecting and tracking targets in clutter. Development of a radar return signal, including a background based on the viewed real-time terrain with clutter superimposed on it, will significantly enhance the ground testing capability for an ISTF. This solicitation is for the development and implementation of the background clutter model, which will eventually be integrated into the Government's Generic Radar Target Generator (GRTG). The characteristics of this clutter model are as follows:> The clutter model should be derived from recognized research and should be theoretically defensible as properly simulating terrain and sea radar returns.> The clutter model should include main lobe clutter (MLC), side lobe clutter (SLC), and altitude line return (ALR). > The clutter will be added to the surface returns of the terrain and have mean backscatter coefficients and amplitude statistics based on topographic data of the terrain, urban or rural. > The angle of viewing should be used in determining the backscatter, scintillation, reflection, and grazing angle effects that account for the amplitude and spectral representation of the main lobe and side lobe clutter. > The clutter model should provide for all reasonable and defensible probability density functions (PDFs). Suggested PDFs include Gaussian, Rayleigh, LogNormal or Weibull, independent, temporally, or spatially correlated. However, it is the responsibility of the vendor to determine which PDFs are needed and desirable. >
The clutter should provide the Doppler components to account for the radial velocity of the radar relative to the clutter surface, the radar antenna pattern, and the texture and slope of the clutter surface. Consideration should be given to both the radar's main antenna beam pattern and the pattern of any guard antenna present. > The clutter characteristics should be predictable and repeatable when viewed from the same angle and velocity.> The clutter model should be capable of generating clutter returns for sea states 0 to 6.The project will be divided into two phases:

PHASE I: The following activities comprise Phase I:> Research the literature and physics that provide the basic mathematical theory for calculating real-time clutter based on the terrain radar return. > Develop the algorithms necessary to generate the real-time radar signal directly from the real-time database information. > Define the processing capability necessary to provide the clutter and superimpose it on the real-time terrain data. > Produce a report that summarizes the above efforts.

PHASE II: The following activities comprise Phase II:> Implement the clutter model algorithms developed in Phase I and produce digital simulated clutter data to drive GFE RF vector modulators to produce composite RF signals. The model will eventually drive the Government's Generic Radar Target Generator, and consideration needs to be given to this fact. > Analyze the effective performance of the simulated clutter. > Produce a report documenting the performance and effectiveness of the real-time, terrain-based-clutter model.

PHASE III DUAL USE APPLICATIONS: The clutter models developed under this effort may be used for development testing for commercial aviation collision avoidance systems and advanced air traffic control radars, and advanced aviation weather radar systems.

REFERENCES:
1. Skolnik, Merrill: "Radar Handbook (Second Edition)", McGraw-Hill Inc, 1990, Chapter 12.
2. Stimson, George W.: "Introduction to Airborne Radar (Second Edition)", SciTech Publishing, Inc., 1998, Chapter V.

KEYWORDS: Radar Clutter, Surface Return, Sea Clutter, Real-time Terrain, Terrain Based Clutter, Airborne Radar

AF02-306 TITLE: Real-Time Infrared (IR) Source Calibration

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Research and develop an IR instrumentation subsystem to measure Infrared (IR) irradiance at specific positions simultaneously and display the results without causing optical interference in the primary optical path.

DESCRIPTION: The project will research and develop a real-time IR measurement device that can be placed in a free-space optical path to monitor IR emissions during operation. The subsystem r should be a passive measurement device that can be operated without obscuring the primary optical path. The output of the monitor should be a user-friendly instrumentation display, shown in real-time giving accurate irradiance levels from the sources being measured.One application for this capability that the Air Force is interested in would place the instrumentation subsystem at the end of an optical path to monitor the calibration of IR sources during real-time testing. The subsystem shall not use transmissive optics or beam-splitters between the infrared sources and the System Under Test (SUT). All infrared sources used have an angular intensity distribution that overfills the area around the SUT, i.e., the source illuminates a 12-inch by12-inch area at the SUT, which is centered in the illuminated area. The SUT resides at the rotation point of a 3-axis flight motion simulator and rides on the pitch and yaw axes. The instantaneous simulation field-of-view from the missile towards the target sources is +/-5 degrees in pitch and yaw. The field-of-regard between the missile dome and the target sources is +/-5 degrees in pitch and yaw. The field-of-regard between the missile dome and the target sources is +/-75 degrees. That is, a small 10-degree cone of a possible 150-degree cone is presented at any one time to the SUT, but that small cone can be located anywhere within the large cone and moves with time. The unused area of the illuminated field can be used for real-time calibration. The infrared monitoring band should span form 1.5 to 5.5 microns. The intensity range can traverse 3 orders of magnitude during a single real-time event and the response of any detector will need to be linear over that range. Though only 3 orders of intensity change occur during a single simulation run, more than 6 orders of magnitude change could occur from one simulation run condition to another. Parallax issues due to placing detectors within the illuminated field, but not exactly at the SUT, need to be addressed. No interference with the field-of-view of the SUT is tolerable, e.g. scattering light. Miniaturization of components is desirable.

PHASE I: Research and analyze development methods and propose a system design. Build a representative deliverable prototype that can be a subsystem of a final product (such as 1 member of an array). Submit a final report covering the research approach, design and results.

PHASE II: Prototype and demonstrate the working instrumentation system.

PHASE III DUAL USE APPLICATIONS: (1) Laser measurement devices. (2) Eye protection. Laser Surgery. (3) IR sensor development.

REFERENCES:

1. "The International Countermeasures Handbook", Englewood, CO, Cardiff Publishing, (most current edition).

2. "The Infrared Handbook", The Infrared Information Analysis (IRIA) Center, Environmental Research Institute of Michigan, (most current edition).

KEYWORDS: Infrared, Instrumentation, Optical, Real-Time, Missile

AF02-307 TITLE: Advanced Airspace Modeling, Characterization, and Planning

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Research, design, and develop an airspace management tool that is capable of correlating previously scheduled air/ground missions to actual real time usage. The system should also be capable of predicting future requirements based on historical and actual airspace usage data.

DESCRIPTION: With increased use of the FAA managed national airspace system (NAS) being all but certain, DOD managers of special use airspace are under increased public pressure to better utilize the airspace under their control. As a result, there is a need for automated, reliable and user-friendly Special Use Airspace Management Systems as well as advanced methods of displaying and analyzing airspace information. Presently, the Air Force Flight Test Center, R-2508 Central Coordinating Facility at Edwards Air Force Base, California uses the Airspace Utilization and Reporting System (AURS) to display limited airspace information within the R-2508 Complex. The system proposed in this investigation is not an extension of current technology but a radically new approach to airspace management and

utilization systems. The proposed system would provide models for aircraft density and better flight route prediction. The system should also provide real time special use airspace information (such as current airspace activity) and aircraft scheduling information within the airspace. Such a system would better aid special use airspace managers make real time prediction on when to release airspace back to the Federal Aviation Administration for joint public/military use. Demands by the airline companies, the Federal Aviation Administration, and the general flying public require that a system capable of depicting an accurate, real time, geographical representation of the airspace and the operations being conducted within that airspace be researched and designed, and developed.

PHASE I: Conduct a feasibility analysis of current and planned airspace utilization systems (both military and commercial systems) to determine the extent the information collected therein can be used to improve airspace management. Research current limitations and constraints (including policy matters) on current airspace management methods and develop alternate solutions to requirements involving airspace management issues. Make recommendations based on surveys of potential users and related technologies. Submit a final report covering the results of findings, analysis and proposed recommendations.

PHASE II: Develop the software to implement airspace management tool for predicting aircraft density and performing fly route planning. Deliver final product and report.

PHASE III DUAL USE APPLICATIONS: This will be a new product with customer applications in the fields of military and airlines route planning, airline hub density predictions and national airspace management by the FAA. Product benefits will also be found in Free-Flight implementation and environmental impact modeling do to aircraft activities.

REFERENCES:
www.faa.gov

KEYWORDS: airspace, airspace management, environmental impact.

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
Submission of Proposals

DARPA's charter is to help maintain U.S. technological superiority over, and to prevent technological surprise by, its potential adversaries. Thus, the DARPA goal is to pursue as many highly imaginative and innovative research ideas and concepts with potential military and dual-use applicability as the budget and other factors will allow.

DARPA has identified technical topics to which small businesses may respond in the second fiscal year (FY) 2001 solicitation (FY 2002.1). Please note that these topics are UNCLASSIFIED and only UNCLASSIFIED proposals will be entertained. Although they are unclassified, the subject matter may be considered to be a "critical technology". If you plan to employ NON-U.S. Citizens in the performance of a DARPA SBIR contract, please inform the Contracting Officer who is negotiating your contract. These are the only topics for which proposals will be accepted at this time. A list of the topics currently eligible for proposal submission is included followed by full topic descriptions. The topics originated from DARPA technical program managers and are directly linked to their core research and development programs.

Please note that **1 original and 4 copies** of each proposal must be mailed or hand-carried. DARPA will **not** accept proposal submissions by electronic facsimile (fax). A checklist has been prepared to assist small business activities in responding to DARPA topics. Please use this checklist prior to mailing or hand-carrying your proposal(s) to DARPA. Do not include the checklist with your proposal.

- DARPA Phase I awards will be Firm Fixed Price contracts.
- Phase I proposals **shall not exceed $99,000,** and may range from 6 to 8 months in duration. Phase I contracts cannot be extended.
- DARPA Phase II proposals must be invited by the respective Phase I technical monitor (with the exception of Fast Track Phase II proposals – see Section 4.5 of this solicitation). DARPA Phase II proposals must be structured as follows: the first 10-12 months (base effort) should be approximately $375,000; the second 10-12 months of incremental funding should also be approximately $375,000. The entire Phase II effort should generally not exceed $750,000.
- It is expected that a majority of the Phase II contracts will be Cost Plus Fixed Fee. However, DARPA may chose to award a Firm Fixed Price Contract or an Other Transaction, on a case-by-case basis.

Prior to receiving a contract award, the small business **MUST** be registered in the Centralized Contractor Registration (CCR) Program. You may obtain registration information by calling 1-888-352-9333 or Internet: http://www.ccr.dlsc.dla.mil and http://www.ccr2000.com/.

The responsibility for implementing DARPA's SBIR Program rests in the Contracts Management Office. The DARPA SBIR Program Manager is Ms. Connie Jacobs. DARPA invites the small business community to send proposals directly to DARPA at the following address:

DARPA/CMO/SBIR
Attention: Ms. Connie Jacobs
3701 North Fairfax Drive
Arlington, VA 22203-1714
(703) 526-4170
Home Page http://www.darpa.mil

SBIR proposals will be processed by the DARPA Contracts Management Office and distributed to the appropriate technical office for evaluation and action.

DARPA selects proposals for funding based on technical merit and the evaluation criteria contained in this solicitation document. DARPA gives evaluation criterion a., "The soundness and technical merit of the proposed approach and its incremental progress toward topic or subtopic solution" (refer to section 4.2 Evaluation Criteria - Phase I), twice the weight of the other two evaluation criteria. As funding is limited, DARPA reserves the right to select and fund only those proposals considered to be superior in overall technical quality and highly relevant to the DARPA mission. As a result, DARPA may fund more than one proposal in a specific topic area if the technical quality of the proposal(s) is deemed superior, or it may not fund any proposals in a topic area. Each proposal submitted to DARPA must have a topic number and must be responsive to only one topic.

- Cost proposals will be considered to be binding for 180 days from closing date of solicitation.

- **Successful offerors will be expected to begin work no later than 30 days after contract award.**

- For planning purposes, the contract award process is normally completed within 45 to 60 days from issuance of the selection notification letter to Phase I offerors.

The DOD SBIR Program has implemented a Fast Track process for SBIR projects that attract matching cash from an outside investor for the Phase II SBIR effort, as well as for the interim effort between Phases I and II. Refer to Section 4.5 for Fast Track instructions. DARPA encourages Fast Track Applications ANYTIME during the 6th month of the Phase I effort. The Fast Track Phase II proposal must be submitted no later than the last business day in the 7th month of the effort. **Technical dialogues with DARPA Program Managers are encouraged to ensure research continuity.** If a Phase II contract is awarded under the Fast Track program, the amount of the interim funding will be deducted from the Phase II award amount. It is expected that interim funding generally, will not exceed $40,000.

To encourage the transition of SBIR research into DoD Systems, DARPA has implemented a Phase II Enhancement policy. Under this policy DARPA will provide a Phase II company with additional Phase II SBIR funding, not to exceed $200K, if a DARPA Program Manager can match the additional SBIR funds with DARPA core-mission funds or the company can match the money with funds from private investors; or at the discretion of the DARPA Program Manager. DARPA will generally provide the additional Phase II funds by modifying the Phase II contract.

DARPA FY2002.1 Phase I SBIR
Checklist

1) Proposal Format

   a. Cover Sheet (formerly referred to as Appendices A and B) **MUST** be submitted electronically (identify topic number) ______

   b. Identification and Significance of Problem or Opportunity ______

   c. Phase I Technical Objectives ______

   d. Phase I Work Plan ______

   e. Related Work ______

   f. Relationship with Future Research and/or Development ______

   g. Commercialization Strategy ______

   h. Key Personnel, Resumes ______

   i. Facilities/Equipment ______

   j. Consultants ______

   k. Prior, Current, or Pending Support ______

   l. Cost Proposal (see Appendix C of this Solicitation). Ensure your cost proposal is signed. ______

   m. Company Commercialization Report (formerly referred to as Appendix E) **MUST** be registered electronically and a signed hardcopy submitted with your proposal (register at http://www.dodsbir.net/companycomercialization) ______

2) Bindings

   a. Staple proposals in upper left-hand corner. ______

   b. **<u>DO NOT</u>** use a cover. ______

   c. **<u>DO NOT</u>** use special bindings. ______

3) Page Limitation

   a. Total for each proposal is 25 pages inclusive of cost proposal and resumes. ______

   b. Beyond the 25 page limit do not send appendices, attachments and/or additional references. ______

   c. Company Commercialization Report (formerly referred to as Appendix E) **IS NOT** included in the page count. ______

4) Submission Requirement for Each Proposal

a. Original proposal, including signed Cover Sheet (formerly referred to as Appendix A) ______

b. Four photocopies of original proposal, including signed Cover Sheet and Company Commercialization Report (formerly referred to as Appendices A, B and E) ______

INDEX OF DARPA FY2002.1 TOPICS

DARPA SB021-001	Continuous Wave Terahertz Source
DARPA SB021-002	Unique Packaging of Exposed MEMS Sensors
DARPA SB021-003	Bistatic Terrain Scattering Model for Microwave SAR Simulation
DARPA SB021-004	Densely Multiplexed Photonic mm-wave Radio Modulator and Demodulator
DARPA SB021-005	Mathematical Methods for Video Registration in Autonomous Navigation Applications
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DARPA SB021-016	Design Tools for Integrated 3-Dimensional Electronic Circuits
DARPA SB021-017	Wide Bandgap Semiconductor (eg., SiC, GaN) Front-End Electronics for Wide Dynamic Range Analog/Digital Converters
DARPA SB021-018	VHF/UHF Endo-Clutter SAR Fiducial Marker
DARPA SB021-019	Airplane Optimal Periodic Flight Control
DARPA SB021-020	Water-Based Thrusters for Space Propulsion
DARPA SB021-021	Tracklet Fusion for strategic GMTI

SUBJECT/WORD INDEX TO THE DARPA FY2002.1 TOPICS

DARPA FY2002.1 TOPICS

DARPA SB021-001 TITLE: Continuous Wave Terahertz Source

KEY TECHNOLOGY AREA: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Technological advancements in the terahertz (10^{12} Hz) region of the electromagnetic spectrum have been hampered by the lack of cost effective sources of terahertz radiation. Applications in ranging, imaging, and communications are just a few of the areas that would benefit from efficient terahertz sources. The objective of this task is to develop a cost effective device to produce continuous wave, coherent, terahertz radiation.

DESCRIPTION: The optical, infrared, millimeter, and microwave portions of the electromagnetic spectrum have been extensively exploited for communications, radar, imaging, and other military and civilian applications. The ability to utilize practical systems in these portions of the electromagnetic spectrum is a result of the availability of cost effective sources and detectors in each spectral region. While terahertz sources do exist, they tend to be bulky and expensive. To date, the available sources consist of extremely large systems, such as free electron lasers, or use pulsed optical radiation to generate pulses of terahertz radiation. While the pulsed radiation has many applications, there is also a need for continuous wave sources in the terahertz range, particularly coherent sources. Without cost effective sources, the terahertz region of the spectrum will remain an interesting area of research confined to specialized applications. Recently, the field of photonic band engineering has emerged as a possible approach to solving the problem of terahertz sources. A photonic band crystal composed of nonlinear optical materials can provide frequency conversion through parametric processes [1]. This approach has been exploited in the near-infrared region of the spectrum to produce coherent electromagnetic radiation [2]. The goal of this solicitation is to develop a cost effective source of continuous wave, coherent radiation in the terahertz region. While an approach based on photonic band engineering is suggested, other methods will be considered if the device is based on sound scientific principles with supporting documentation.

PHASE I: Clearly demonstrate the feasibility of the proposed approach to generate continuous wave, coherent terahertz radiation. Provide a detailed description of the theory of operation and an in depth discussion of fabrication issues and testing methods.

PHASE II: Building upon the Phase I effort, develop a prototype device. Perform appropriate testing and analysis to demonstrate operation of the device, develop operational concepts and procedures, and provide a pathway for commercial development of devices based on this concept.

PHASE III DUAL USE APPLICATIONS: The resulting prototype device will serve as a basis for development of commercial systems. Applications for terahertz radiation include communications, collision avoidance for airborne and ground based vehicles, atmospheric sensing, medical imaging, ranging, and spectroscopy.

KEYWORDS: Terahertz Devices, Terahertz Sources, Communications, Atmospheric Sensing, Photonic Band Engineering, Medical Imaging, Spectroscopy, Optical Parametric Oscillator.

REFERENCES:

1. M. Centini, et al, Optics Communications, Volume 189, p. 135 (2001).
2. Y. Dumeige, et al, Applied Physics Letters, Volume 78, p. 3021 (2001).

DARPA SB021-002 TITLE: Unique Packaging of Exposed MEMS Sensors

KEY TECHNOLOGY AREA: Sensors, Electronics and Battlespace Environment

OBJECTIVE: To develop novel, low-cost packaging processes and designs for MicroElectroMechanical Systems (MEMS) sensors that require exposure to the environment for operation, such as humidity and adverse chemical sensors for missile health monitoring applications.

DESCRIPTION: With increasing developments in MicroElectroMechanical Systems (MEMS), new sensing techniques and devices are emerging rapidly. However, significant deterrents to military application of many of these devices exist. One area of primary concern exists with environmentally exposed micro sensors, such as humidity sensors and adverse chemical sensors. In order for these devices to accurately measure the parameter at issue, they must be exposed to the environment, producing an inherent reliability risk. Additionally, many packaging schemes, such as cylindrical sidewall protectors, create board-yield risk due to trapped fabrication processing liquids or debris. Furthermore, packaging of these sensors makes them cost prohibitive in many cases. For example, a MEMS humidity sensor die is easily producible for \$1 – \$3 each, yet a packaged MEMS humidity sensor, ready for printed circuit board (PCB) mounting, costs \$100 – \$200 each. This is unacceptable. Therefore, a technology barrier in packaging and/or mounting techniques must be breached to make these MEMS sensing devices cost effective and reliable. Due to the broad applicability of MEMS devices to so many various systems, there will not be a one-size-fits-all

package or universal form of package. The package itself, since it is also a miniature system, couples into the MEMS system and greatly effects performance. Various package styles and techniques will affect the thermal, electromagnetic interference (EMI), mechanical stress, and reliability characteristics of the sensors in various ways. Therefore, MEMS packaging technologies should be explored, to the extent that a wide variety of techniques exist, and a selection of package styles or techniques can then be used in a particular application. This situation has occurred in the microelectronics arena where a system designer can now get surface-mount technology (SMT), Through-hole, Flip-Chip, standard outline (SO), single small outline (SSO), plastic leadless chip carrier (PLCC), J-Lead, and many other package styles all with different performance characteristics and costs. The designer can then fit those into the application as is seen fit. The problem of MEMS packaging is almost as broad a research area as is development of MEMS devices. Many organizations are currently exploring various aspects of packaging by investigating the use of new materials, new processes, new package designs, and new standards to aid in the packaging of humidity, temperature, and acceleration sensors. However, chemical sensors are an entirely different type of device with very unique packaging requirements. In addition, different sensors for different chemical species may have differing packaging requirements. For micro-optical systems, some packaging techniques used in opto-electronics packaging can possibly be modified for use in MEMS devices. However, these techniques have been developed for the telecomm industry, are not required often, and are still extremely expensive. Batch fabrication, active alignment, and automated placement are all techniques that could reduce packaging costs associated with micro-optical systems. Proposals should address as many exposed sensor types as possible in accordance with the issues above. Award consideration will be based heavily upon the completeness of addressing the named concerns, the innovative nature of the technology proposed, the economical advantages of the device(s) and process(es) proposed, the applicability of the devices to both military and commercial uses, and the performance specifications/expectations of the packaged sensor(s).

PHASE I: Identify specific packaging requirements and techniques for MEMS sensors, addressing particularly those sensors requiring exposure to the environment. Develop a detailed approach and schedule for maturing MEMS packaging technologies. Design packaging concepts and verify MEMS die and package integration feasibility via modeling. Define theoretical limitations of, and any technological barriers to implementation of, your concept (including such parameters as packaging effects on performance, size, reliability, cost, etc.). Quantify the advantages of your approach, and conduct proof-of-principle experiments to verify proposed techniques. All devices must ultimately demonstrate reliability over a temperature range of -57°C to +95°C for a 10-year life.

PHASE II: Illustrate analytical concepts that demonstrate the capability of the proposed technology(ies) and provide robust, low-cost, ultra-reliable MEMS sensing devices for military applications. Validate your Phase I concepts by packaging prototype MEMS sensors for military applications. Teaming with government, industry, or academia foundries as necessary is encouraged. Confirm performance through laboratory testing and quantify performance specifications for the packaged micro-devices.

PHASE III DUAL USE APPLICATIONS: The dual use potential of the product(s) from this effort is phenomenal. Markets extend from numerous automotive, aeronautical and robotic applications to mining and oil-drilling applications to medical and food industry applications. Potential market sales of packaged, small, low-cost conformal environmental and inertial sensing devices are astronomical.

KEYWORDS: MEMS, Sensors, Packaging, Micro-Optics, Materials.

REFERENCES:

1. Department of Defense, "Microelectromechanical Systems: A DoD Dual Use Technology Industrial Assessment," December 1995.

DARPA SB021-003 TITLE: Bistatic Terrain Scattering Model for Microwave SAR Simulation

KEY TECHNOLOGY AREA: Information Systems Technology

OBJECTIVE: Develop parametric innovative bi-static terrain scattering models to cover L-band through Ku-band scattering at arbitrary polarization. A variety of vegetation types including leaves, stalks, twigs, etc requires new theoretical development as well as new ideas for software implementation and run-time efficiency. Models must support a variety of terrain type and roughness and vegetation cover. Develop a scene simulation that makes use of Digital Terrain Elevation Data (DTED) and Land-Cover/Land-Use databases to simulate bi-static Synthetic Aperture Radar (SAR) maps. Simulation must be capable of being embedded into a SAR system simulation.

DESCRIPTION: Bi-static SAR concepts offer the capability for covert passive operation. Missions include improved battlefield awareness, support for Special Operations, target detection, and precision targeting. The use of large bi-static angles offers significant advantages for enhanced terrain scattering and interferometric height sensing accuracy. A few bi-static terrain scattering models have been developed for a limited terrain, and a limited amount of experimental data has been collected. In addition, comprehensive worldwide databases exist from which realistic terrain slopes, and cover are available. Performance of current and future sensor programs depends critically upon the characteristics of terrain scattering. Sensitivity to local slope,

dielectric properties, polarization, resolution, and the degree to which these effects will affect sensor products are of concern. A single innovative and creative simulation capable of modeling a variety of terrain and system parameters, which is flexible and highly automated, is essential to the success of these sensor programs. By federal regulation governing SBIR's, "Rights in technical data, including software, shall remain with the contractor, except that the government shall have the limited right to use such data for government purposes and shall not release such data outside of the government without the permission of the contractor for a period of five years from completion of the project from which the data was generated, unless the data has already been released to the general public. However, at the end of the five-year period, the government shall retain a royalty-free license for government use of any technical data delivered under the contract."

PHASE I: Develop and implement in a widely available and transportable source code, innovative and creative models sufficient to describe realistic bare earth and vegetated terrain over the range of sensor parameters described above. Select, collect and display DTED and land cover databases to be used in a simulation to be developed in Phase II.

PHASE II: Develop a simulation of bi-static SAR making use of the innovative and creative clutter models and interfaces with existing database developed in Phase I.

PHASE III DUAL USE APPLICATIONS: SAR finds application in military surveillance and commercial remote sensing. The use of scattering geometries other than backscatter allows passive operation, which is important to the military, and potentially offers a more general remote sensing capability. In either case, realistic characterizations of terrain scattering are critical to both the design of these systems and utility of the products that they generate.

KEYWORDS: Bi-static, SAR, Resolution, Imagery, Clutter, Remote Sensing.

REFERENCES:
1. H. T. Ewe and H. T. Chuah, "Electromagnetic Scattering from An Electrically Dense Vegetation Medium," IEEE Transactions on Geoscience and Remote Sensing, Vol. 38, No. 5, September, 2000.
2. R. J. Papa, et. al, "The Variation of Bistatic Rough Surface Scattering Cross Section for a Physical Optics Model," IEEE Transactions on Antennas and Propagation, Vol. AP-34, No. 10, October, 1986.
3. M. Y. Xia, et. al, "Wavelet-Based Simulations of Electromagnetic Scattering from Large-Scale Two-Dimensional Perfectly Conducting Random Rough Surfaces," IEEE Transactions on Geoscience and Remote Sensing, Vol. 39, No. 4, April, 2001.

DARPA SB021-004 TITLE: Densely Multiplexed Photonic mm-wave Radio Modulator and Demodulator

KEY TECHNOLOGY AREA: Sensors, Electronics and Battlespace Environment

OBJECTIVE: Develop a photonic mm-wave radio modulator and demodulator to support high frequency broadband wireless networks.

DESCRIPTION: In the future, an ad hoc mm-wave wireless communications system will network a large number of battlefield elements. The ability to support large numbers of nodes requires maximally efficient use of the available radio frequency (RF) spectrum. Some promising schemes for efficient spectral usage depend on low phase noise carrier generation with wideband modulation bandwidth. For example, an extension of cell phone code division multiple access (CDMA) encoding with high M-ary phase shift keying would support large numbers of nodes in a cell. Emerging photonic low phase noise carrier generation schemes and electro-optic modulators [refs] are good candidates for such systems.

PHASE I: Design a photonic mm-wave signal modulator and demodulator operating at 38 GHz and perform a proof-of-principle experiment to demonstrate efficient spectral usage.

PHASE II: Design, fabricate and demonstrate a densely multiplexed mm-wave photonic modulator/demodulator. Use the demonstration and analysis to determine the limits of channelizing using this approach.

PHASE III DUAL USE APPLICATIONS: The technology developed under this SBIR can be used to offer a wireless last mile Internet connection product to businesses in urban areas where fiber infrastructure is expensive. It may be used to expand the number of channels offered by Local Multipoint Distribution Service (LMDS) at 28, 38 and 40 GHz bands.

KEYWORDS: MM-Wave, Wireless Communications, Photonic, Bandwidth, RF, Radio Frequency.

REFERENCES:
1. L. Noel, D. Wake, D. G. Moodie, D. D. Marcenac, L. D. Westbrook, and D. Nesser, "Novel Techniques for High Capacity 60 GHz Fiber Radio Transmission Systems," IEEE Transactions on Microwave Theory and Techniques, v. 45, no. 8, p. 1416, 1997.

DARPA SB021-005 TITLE: Mathematical Methods for Video Registration in Autonomous Navigation Applications

KEY TECHNOLOGY AREA: Sensors, Electronics and Battlespace Environment

OBJECTIVE: Develop robust technology for registration of video imagery with database imagery that is based on rigorous mathematical foundations and is applicable to autonomous or semi-autonomous vehicle navigation.

DESCRIPTION: Automation of navigation functions, including such sophisticated tasks as landing of unmanned air vehicles (UAVs), avoidance of terrain, and routing of cruise missiles to distant targets without reliance on Global Positioning System (GPS) data, is increasingly important in numerous Defense applications. In situations where a database of reference imagery is available, reliable and computationally efficient means for registration of real-time video sensor data with reference imagery can provide the foundation for autonomous navigation. This effort seeks to develop and demonstrate mathematically sound methodologies for image registration that are suitable for computationally efficient implementation and are robust with respect to rotation and perspective, partial occlusion, unknown and incomplete scene overlap, temporally-based variations, and other inconsistencies between acquired and archived images and image sequences. Several approaches for registration of images, including both direct correlation and feature-based methods, have been described in the research literature (see [1] for a survey) and some attention has been given to various robustness issues [2,3]. Among those methods that have solid mathematical foundations, little attention has been given to issues of computational efficiency, which are crucial for real-time applications such as automated aircraft landing [4] and are expected to hinge on innovative mathematical approaches to data dimensionality reduction.

PHASE I: Define a mathematically sound, robust, and computationally efficient approach for registration of images with an imagery.

PHASE II: Implement a prototype system capable of supporting significant proof-of-concept demonstrations involving actual database imagery and real-time or simulated real-time imperfect image sensor data.

PHASE III DUAL USE APPLICATIONS: The methodology, specific algorithms, and software developed will have applications to autonomous or semi-autonomous navigation of air, ground, and undersea vehicles in a wide variety of Defense and other settings. In the Defense context, potential applications include autonomous navigation of cruise missiles and other UAVs, navigation of Unmanned Undersea Vehicles (UUVs), and automated landing systems for UAVs. Numerous possible commercial products based on the algorithms include robotic systems for surveying and search, computer tools for image and video data mining for criminology (e.g., matching security camera video to mugshot databases), and automated security patrolling equipment.

KEYWORDS: Sensors, Video, Registration, Navigation.

REFERENCES:

1. Brown, L.G., "A survey of image registration techniques," ACM Computing Surveys, vol. 24(4), pp. 325--376, 1992.
2. Monasse, P., "Contrast invariant image registration," Proceedings of the IEEE International Conference on Acoustics, Speech, and Signal Processing, pp. 3221—3224, 1999.
3. De Castro, E. and C. Morandi, "Registration of translated and rotated images using finite Fourier transforms," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 5(2), pp. 700—703, 1983.
4. Dickmans, E.D. and F.R. Schell, "Autonomous landing of airplanes by machine vision," Proceedings of the IEEE Workshop on Applications of Computer Vision, pp. 172—179, 1992.

DARPA SB021-006 TITLE: Novel Concepts for Soldier-Centric Technology in Non-Traditional Combat Casualty Care

KEY TECHNOLOGY AREA: Biomedical

OBJECTIVE: To develop novel medical technology that allows the individual warfighter to overcome acute battlefield injuries in an austere and isolated environment.

DESCRIPTION: Statistics show that relatively minor injuries are responsible for nearly two-thirds of combat casualties in the battlefield. Nonetheless, even these minor injuries often lead to evacuation, which compromises the unit and can lead to mission failure. Hemorrhage accounts for forty percent of deaths in the battlefield. Technology that allows the warfighter to stabilize his injury and overcome his immediate need for classical medical care will result in a reduction in morbidity and mortality in the battlefield, and an increase in soldier persistence. These concepts must focus on automated diagnostic and therapeutic capabilities to allow a non-medic warfighter to overcome operational combat hazards from conventional munitions, laser weapons, chemical weapons and radiation. Ultimately these technologies must be light enough to carry in a backpack, or incorporated into the soldier's Battle Dress Uniform (BDU).

PHASE I: Phase I research will investigate novel technologies that could allow the soldier to have the capability for immediate diagnosis, treatment, pain control, stabilization of injury and accelerated tissue repair.

PHASE II: Specific technologies will need to be augmented into existing soldier-borne platforms using non-invasive devices. An example for hemorrhage control may be flexible garment-based materials to transform into rigid "exo-splint" like devices to stabilize a long bone or cervical neck fracture. Tourniquets are difficult to apply as a "self-aid" device, novel concepts may be considered as an automated "G-suit" (tourniquet-like device) that would provide proximal external compression to specific areas of bleeding for hemorrhage control. Operational combat hazards of interest include self-diagnosis for pneumothorax, heat/cold stress, toxin exposure, internal bleeding and musculoskeletal injuries. Acceleration of tissue repair in a battlefield environment using electromagnetic fields such as near infrared, millimeter waves and radio frequency would enable a functioning soldier in a combat environment.

PHASE III DUAL USE APPLICATIONS: Commercial applications of this wide spectrum of technology could include skin care, trauma management, and chronic pain therapy in hospitals and outpatient clinics. This self-aid technology would transition to use by forest firefighters, outdoor recreational adventurers and others in remote locations where medical aid is not readily available.

KEYWORDS: Electromagnetic Therapy, Tourniquets, Splints, Acceleration of Healing, Stabilization of Injury.

REFERENCES:

1. Textbook of Military Medicine Anesthesia and Perioperative Care of the Combat Casualty. 1995. *Office of the Surgeon General, Department of the Army, United States of America.*

DARPA SB021-007 TITLE: Quality Water Lubrication of Special Triboceramics, Alloys and Self-Lubricating Composites

KEY TECHNOLOGY AREA: Materials / Processes

OBJECTIVE: The objective of this study is to lay the groundwork of tribological fundamentals for advanced water-lubricated steam engines intended for both mesoscale and macroscale use. The main goal here is to determine the load/speed/temperature (to 100 deg. C) dependent friction and wear of (a) triboceramics, which in the presence of water form lubricative surface substances (e.g., aluminum hydroxide on the top of alumina hydrated silica on the top of silicon nitride and silicon carbide), (b) metal alloys resistant to gross water-induced corrosion, but which in the presence of water form benign corrosion products (such as hydrated oxides-hydroxides) which could be construed as lubricative at low to moderate Hertzian stresses, and (c) other self-lubricating materials (e.g., certain forms of carbons, graphites and polymeric composites, which act as structural tribomaterials in the presence of water.

DESCRIPTION: If sufficiently high power densities can be achieved by the judicious use of design and selection of materials, the use of advanced steam engines, where both the working fluid (steam) and the lubricant (water without or with special water-compatible additives) are water, is highly desirable both for military and civilian applications. The ultra-quiet and ecologically advantageous nature of steam engines could allow the design and development of motors. The contractor must have the appropriate environmental tribotest apparatus to approximate the realistic loads, speeds and temperatures one would normally find in advanced steam engines during tribometry of the various likely commercially available and specially formulated and commercially available materials. The materials must be paired in realistic tribosystems one could expect to find in piston or turbine-operated engine designs, first in a pure water and steam, and later in additive-containing liquid and vapor phase environment. The results must be presented in wear maps describing the performance of the various tribomaterials in terms of load/speed/temperature-dependent friction values and wear rates as m^3/Nm of sliding, so designers can create likely materials and configurational variations necessary for the various likely Hertzian contact configurations of steam engine moving mechanical assembly components.

PHASE I: Identify those ceramics, metallic alloys and self-lubricating composites, which lend themselves best for the defined load/speed/temperature/sliding mode (unidirectional or oscillatory) and water/steam environment of the most appropriate tribosystem combinations. Select at least one point-contact and one area-contact environmental tribometer, by which the Hertzian stress-, sliding velocity-, and thermal-atmospheric environment-dependent tribological properties of these materials can be determined. Select at least two different ceramics, two metallic alloys and two self-lubricating composites to preliminarily determine these parameters to the limiting PV (pressure-velocity) and thermal-environment limit characteristic to these materials, using pure water and steam atmosphere environment at or somewhat higher than 100 deg. C. Rationalize the selection of the most likely tribomaterials and justify the down select of the final candidates for friction and wear testing by supplying key review articles, technical papers or other pertinent references.

PHASE II: Based on the results of Phase I, map the entire likely triboenvironmental regime of each of the six model materials using the test apparatus and pure water/steam environment employed in Phase I to establish a baseline for a wider screening study using other likely, commercially available and specially formulated tribomaterials analogous to the model ceramics, alloys and self-lubricating materials but with vastly improved properties. Prediction of the improved properties must

be made by known friction, wear and lubrication principles combined with the knowledge of the behavior of structural materials in a high temperature water and steam environment. Search the literature for the best water-compatible additives, which might be able to reduce the tribochemical wear of the six model materials, and perform friction and wear testing in water-additive and steam-additive environments to demonstrate the possible reduction in friction and wear rate as a function of additive chemistry and content.

PHASE III DUAL USE APPLICATIONS: The use of advanced steam engines, where both the working fluid (steam) and the lubricant (water without or with special water-compatible additives) are water, is highly desirable both for military and civilian applications. This would include military and commercial generators and power plants as well as both military and commercial vehicles.

KEYWORDS: Water-Lubrication, Tribology.

REFERENCES:

1. "Sliding Friction and Wear of Ceramics in Neutral, Acid, and Basic Aqueous Solutions," B. Loffelbein, M. Woydt and K. H. Habig, Wear, (1993), 162-164, 220-228.
2. "Tribochemical Mechanism of Alumina with Water," R. S. Gates, S. M. Hsu, E. E. Klaus, Tribology Transactions, vol. 32, (1989), 3, 357-363.
3. "Tribochemistry of Silicon-Based Ceramics under Aqueous Solution," K. Mizuhara, S. M. Hsu, Eurotrib. 93, vol. 3, (1993), 52-57.
4. "Silicon Nitride Boundary Lubrication: Lubrication Mechanism of Alcohols," R. S. Gates, S. M. Hsu, Tribology Transactions, vol. 38, (1995), 3, 648-653.
5. "Friction and Wear of Silicon Nitride and Silicon Carbide in Water: Hydrodynamic Lubrication at Low Sliding Speed Obtained by Tribochemical Wear," H. Tomizawa, T. E. Fischer, ASLE Transactions, vol. 30 (1987), 1, 41-46.
6. "The Transition of Wear Mode During the Running-In Process of Silicon Nitride Sliding in Water," Wear, vol. 205 (1997), 55-63.
7. "Water Lubricated Sliding Wear of Ceramics Si_3N_4 and Al_2O_3 against Gray Cast Iron," Y. M. Gao, L. Fang, L. Zhou, J. T. Su, Mechanical Engineer, Vol. 32 (1996), 2, 8-12.

DARPA SB021-008 TITLE: Detecting Misleading Information

KEY TECHNOLOGY AREA: Information Systems Technology

OBJECTIVE: Develop and demonstrate intelligent agent software capable of detecting (intentionally) misleading information from potential threat groups in open sources.

DESCRIPTION: Techniques for intelligence gathering from open sources recognize that open source information is 100% consistent, accurate and reliable; however, they do not adequately address the possibility that it may be intentionally inaccurate. Inaccurate information might be posted regarding transactions, payments, contacts, members, roles, employment/affiliation history, education, background, front companies, business partners, business volume, business types, contracts, etc. This inaccurate information is designed not only to hide the true capabilities and intentions of a terrorist group, but also to make it appear legitimate. What is needed is intelligent agent software that is capable of reviewing web sites and identifying implausible or inconsistent information, such as companies who claim contracts incommensurate with their business history or size, companies who make unverifiable claims, persons who have "missing periods" in their background, persons whose positions are inconsistent with their experience, transactions inconsistent with the type, location, or nature of a business, etc. Such agents would be specific to particular domains of interest and likely would rely on a large amount of domain-specific knowledge. They would have to avoid high false-alarm rates. A set of such agents, specific to different domains, would work together to achieve high true-positives while avoiding high false alarms. The results of work performed under this SBIR would have to demonstrate the ability to find useful leads related to actual potential threats. It should allow for the incorporation of specific threat information so the agents could find misleading information that may indicate activities by these threat organizations or people. Research advances are needed in reasoning about adversaries, use of background knowledge, temporal reasoning, and common-sense reasoning.

PHASE I: Determine feasibility of distinguishing misinformation from accurate or unreliable information by conducting experiments on selected corpus of data from internet sites and other open sources. Identify characteristics of data that affect performance goals.

PHASE II: Implement prototype software to demonstrate the ability to detect misinformation in a real-time internet-based environment, using selected sites (e.g., news providers, organizational sites, etc.). Evaluate by constructing receiver operating characteristic (ROC) curve for precision-recall tradeoff.

PHASE III DUAL USE APPLICATIONS: Techniques for detecting intentionally misleading information are useful not only for military forces but also for regulatory and commercial organizations. HCFA (Health Care Financing Administration) could use

these techniques for Medicare fraud detection. The SEC (Securities & Exchange Commission) could use these techniques for detection of stock frauds, the FTC (Federal Trade Commission) for detection of anti-competitive behavior. Commercial organizations could use these techniques for business intelligence gathering about their competitors' plans and capabilities. Personnel departments could use these techniques to verify claims on resumes. Insurance companies could use them for investigations of fraudulent claims.

KEYWORDS: Information Warfare, Fraud Detection, Activity Monitoring, Pattern Detection, Adversarial Reasoning, Common-Sense Reasoning, Plausible Reasoning, Evidential Reasoning, Information Operations.

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DARPA SB021-009 TITLE: Modeling Asymmetric Economic Threats to Critical DoD Technology Sectors

KEY TECHNOLOGY AREA: Information Systems Technology

OBJECTIVE: Develop an effective and valid family of predictive models that will effectively project asymmetric threat factors that could individually or in aggregate adversely affect economic stability of critical DoD technology sectors. The model shall be capable of projecting trends and interactive effects of projected trends, as well as presenting prevention/intervention strategies.

DESCRIPTION: In 1997, the FBI Director Louis Freeh testified to Congress that foreign companies from 23 nations were involved in the illicit acquisition of US trade secrets and that 12 of those countries have aggressively "targeted US proprietary economic information and critical technologies." A recent American Society for Industrial Security (ASIS) report estimated that the number of cases of industrial espionage directed at U.S. technology industries have grown 260% since 1985 and is currently estimated at over $410 billion a year. The primary targets include, but are not limited to, biotechnology; aerospace; telecommunications, including the technology to build the National Information Infrastructure; computer software and hardware; advanced transportation and engine technology; advanced materials and coatings, including "stealth" technologies; energy research; defense and armaments technology; manufacturing processes; and semiconductors. These industries are of strategic interest to the United States on three levels: 1) they produce classified products for DoD; 2) they produce dual-use technology used in both the public and private sectors; and 3) they are responsible for R&D and creation of leading-edge technologies critical to maintaining U.S. technological dominance. Losses at any of these levels could affect U.S. international competitiveness and security. To adequately identify and counter emerging external economic threats to critical DoD technology sectors, it is necessary to develop new models capable of projecting global as well as national technology sector trends, the corresponding external factors contributing to such trends, and the variables that can directly or indirectly be manipulated to adversely affect our national security. To date, asymmetric warfare modeling attempts have not focused on threats to our technological vulnerability through economic stability. Predictive technologies based on organizational behavior, in general, are still in the development stage. To meet the objectives of this SBIR, research may include existing models or combinations of models, as well as newly developed models, as applied to this new focus.

PHASE I: Conceptualize and describe valid economy predictions and intervention models that can identify variables that can affect the critical DoD technology sectors and can be manipulated within an asymmetric framework. The model will emphasize how such identified variables may result in an increased asymmetric threat to stability and how prevention and intervention may be used to reduce or eliminate such threat.

PHASE II: Develop and apply an implementation of the proposed model. The model will be based on relevant historical data and will be capable of identifying key variables that have adverse effects on national economic stability. Second, the model will be capable of projecting vulnerabilities from an asymmetric warfare perspective, as well as generating prevention and intervention scenarios. The implementation must include complete documentation to allow for direct replication of methods and results across a variety of threats to economic stability.

PHASE III DUAL USE APPLICATIONS: The development of an effective economic model will allow for more accurate anticipation of asymmetric threats to national economic stability. The generation of probable prevention and intervention scenarios would be useful in the event that asymmetric threats are realized. A valid model will present multiple opportunities for commercial applications such as decision aids and training tools for investment and market sector analysis for private industry. Such applications would provide means by which countermeasures to identified threats could be developed and implemented to decrease the probability of asymmetric threat. The model and prevention/intervention scenario generation would have utility from both corporate and government proactive perspectives.

KEYWORDS: Economic Stability, Asymmetric Warfare, Threat Assessment.

DARPA SB021-010 TITLE: Modeling Organizational Behavior within Operations Other than War

KEY TECHNOLOGY AREA: Information Systems Technology

OBJECTIVE: Develop a family of adaptive organizational models representing the key organizational components (e.g., rogue nations, civilian populations, non-governmental organizations, coalition forces) to support mission planning and rehearsal for Operations Other Than War (OOTW).

DESCRIPTION: With the fall of Soviet communism in 1989, the bipolar world that very much defined our national defense strategy disappeared. Other than the Gulf War, our military emphasis has been dominated by OOTW actions such as peacekeeping, peace enforcement, nation building, disaster relief, etc. While today's physics-based maneuver and attrition models proved valuable in preparation for Desert Storm, their inability to address the behavioral component of the myriad of OOTW participants were noticeably absent during preparation for Bosnia and Kosovo. Research advances in the area of organizational and behavioral modeling offer potential enhancements to the mission planning and rehearsal capability for OOTW. However, there still remain some significant challenges to modeling the robust characteristics necessary to adequately represent and provide an OOTW planning and rehearsal capability. Technology shortcomings include modeling non-doctrinal organizations, organizational dynamics, and behavior moderators that stimulate organizations to act and then to act in a specific way. In an effort to meet the objective of this SBIR, research may draw upon existing models, architectures, and techniques or create new ones. However, the approach should yield a significantly enhanced mission planning and rehearsal capability in the following areas: behavior models tailorable to new populations and cultures; behavior models tailorable to new rules of interactions, and automated development of recommended courses of action with links to key decision parameters.

PHASE I: Create and describe a conceptual model of key organizational components based on behavioral and scientific modeling strategies and methodologies, including a clear description of the metrics to be used to demonstrate the reliability and validity of the proposed model. The description shall indicate how the model will be generalizable across organizations. Furthermore, the description shall indicate how the model test bed may be applied to specific situations and events from regional and cultural perspectives.

PHASE II: Create an implementation of the models to embody complete functionality of the components being demonstrated and validated; provide complete documentation of test cases and validation results.

PHASE III Dual Use Applications: The development of organizational modeling algorithms and technologies will have a very strong commercial potential with applications such as municipal planning, law enforcement (security agencies such as FBI, DEA, Secret Service), emergency management response (FEMA), international corporations, and non-government organizations (Red Cross).

KEYWORDS: Operations Other Than War, OOTW, Cognitive Modeling, Behavior Modeling, Organizational Modeling, Mission Planning, Mission Rehearsal.

DARPA SB021-011 TITLE: Multi-Modal Control for Automatic Vehicle Management Systems

KEY TECHNOLOGY AREAS: Air Platforms, Information Systems Technology, Ground and Sea Vehicles, Human Systems

OBJECTIVE: Devise provably safe and certifiable control technologies for automatic mode transitions involving manual and automatic controls for moving vehicles, on land, sea, or air.

DESCRIPTION: Advanced vehicle management systems (VMS) are now capable of fully autonomous control of automated highway vehicles, unmanned ground vehicles (UGVs), surface craft, and manned and unmanned aircraft. However, many of these vehicles also operate, at various times or in different conditions, either manually or in various degrees of autonomy. Such conditions include fault recovery, takeoff and landing, high traffic, or in extreme and emergency situations. Manual operation may take the form of on-board operation (i.e., optionally-piloted vehicles), or through remote control, though the emphasis here is on optionally piloted vehicles as opposed to teleoperation. Technology is needed to manage the transition between automatic and manual control, switching between different levels of autonomy, and the underlying stability and control mechanisms that permit safe and reliable operation in mixed manned/unmanned environments. Such technologies include integrated autonomous/manual hybrid control systems, innovative situation awareness to include intra- and extravehicular states, multi-vehicle sensing and information technology, tools for intelligent autonomous-mode fault detection and mitigation, connectivity to mission management systems, multi-mode instrumentation, and control inputs. Common to all these areas will be the need for high-confidence, certifiable control software.

PHASE I: Identify provably stable transition control technologies for manual/autonomous and variably autonomous modes of operation. Determine implications for user interface design; control input devices, and information transfer. Demonstrate correctness and safety in a wide range of simulated hazard, mode transition, and mission phase transitions.

PHASE II: Implement and demonstrate a variably autonomous vehicle controller for an optionally piloted air or land vehicle. Prove stability and correctness bounds in a variety of failure modes and operator intervention scenarios. Consider

psychophysical effects such as driver/rider comfort and performance limitations in automated passenger vehicles. Address certifiability of the resulting design.

PHASE III DUAL USE APPLICATIONS: The technology developed under this SBIR may be used in automated vehicles, personal transportation, civil and military UAVs and UGVs, and for manned vehicles that are operated with full or partial manual control for testing and evaluation purposes.

KEYWORDS: Autonomy, Automated Vehicles, Personal Transportation, Hybrid Control Systems, Flight Control Systems, Vehicle Management Systems.

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DARPA SB021-012 TITLE: Tools for Design and Validation of Quantum Algorithms and Protocols

KEY TECHNOLOGY AREA: Information Systems Technology

OBJECTIVE: Develop software tools to aid in the design and validation of algorithms and protocols for the use and transmission of quantum information.

DESCRIPTION: Quantum information systems for computation and communication are of increasing interest in both military and commercial applications. Design of algorithms and protocols for quantum systems presents new challenges, including: novel fundamental operators; the probabilistic nature of many quantum algorithms and protocols; the diversity of possible implementations of quantum information; and inherent faults such as decoherence that must be tolerated. In addition to new algorithms and protocols, variants of existing ones are needed, both for expanded applicability and for implementation reasons. For example, the quantum Fourier transform that is at the heart of Shor's factoring algorithm [1] has also been applied to finding the order of a permutation [2]. As another example, the BB84 protocol [3] for key distribution must be augmented for implementation by adding intrusion detection, privacy amplification, and other modifications. Finally, depending on the implementation, any algorithm or protocol will need to be modified for control of implementation-dependent errors. Software tools are needed, both to meet the design and validation challenges for new quantum algorithms and protocols, and to ease the construction and validation of new variants of existing algorithms and protocols. Tools may include simulators, visualization tools, languages and translators, timing estimators, and other software.

PHASE I: By the end of Phase I, the expected accomplishment is an architecture for a tool or tool suite, together with evidence that the tools could be applied to a non-trivial quantum algorithm or protocol such as Shor's factoring algorithm. The tools should aid in the construction of a variant of the algorithm, or in understanding the correctness, performance, or other properties of the algorithm.

PHASE II: By the end of Phase II, use of prototype tools should be demonstrated in designing or validating a new quantum algorithm, protocol, or variant.

PHASE III DUAL USE APPLICATIONS: Quantum information systems have the potential for greatly improved performance in areas such as information security and the solution of computationally hard problems. Military and commercial applications are very similar; they include secure communication, signal and image processing, and solution of logistical problems. The tools developed under this program will aid in modifying the underlying algorithms for specific applications, and in validating their properties in those applications.

KEYWORDS: Quantum Information, Quantum Computing, Algorithms, Protocols, Simulation.

REFERENCES:

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2. Order of a permutation: http://xxx.lanl.gov/ps/quant-ph/0007017.
3. BB84: http://xxx.lanl.gov/abs/quant-ph/9811056.

DARPA SB021-013 TITLE: Reading Signs in Context to Support Perception–Based Autonomous Navigation

KEY TECHNOLOGY AREA: Information Systems Technology

OBJECTIVE: Develop software algorithms to employ a robotic vehicle's sensor suite to detect, localize, track, and read any textual or graphic signboards in the robot's environment. Integrate these sign reading algorithms into a representational and reasoning infrastructure that can reason about the sign and also its environmental context in order to support the selection of appropriate autonomous navigation behaviors.

DESCRIPTION: Human beings are able to navigate confidently in highly complex environments because of their robust perceptual capabilities, which allow them to recognize specific places and to reason about relationships between them. This capability is enhanced, in both outdoor and indoor environments, through the use of signboards presenting text and/or graphical information. When effectively deployed, signboards provide unambiguous information that humans rely on to know where we are and how to get to where we want to go. Signs are used to provide explicit location and direction references (street names and room numbers), behavior instructions (stop signs), and warnings (safety notices). Providing a robot with the ability to read and understand the signs that it encounters in its environment will greatly enhance the robustness of its autonomous navigational capabilities. Signboards, by virtue of the fact that they are intended to be noticed and understood, possess canonical structural features (placement, size, shape, color, and text and/or graphical design) that facilitate the task of "parsing" them from the robot's sensory scan of its environment. Once recognized, signs can serve as highly reliable navigational landmarks, in addition to providing their semantic content. Automated recognition of license plates is now used for law enforcement, and recognition of traffic signs has also been pursued, most notably in Europe and Japan, and mostly based on template matching. This new effort is intended to provide broader-based tools that can move beyond these specific sign types to also deal with signs in indoor environments and with the various other types of signs (e.g., commercial) that humans employ.

PHASE I: Design and implement initial software algorithms to detect, localize, track, and read any textual or graphic signboards in the robot's environment. Characterize the sensor performance (e.g., resolution, speed, range, lighting) required by the sign reading algorithms. Characterize performance levels as a function of relative orientation and distance. Develop a conceptual design for representational and reasoning infrastructure elements to determine whether a sign is situated appropriately in its environment, to capture its semantic content, and to validate its applicability to the robot's navigation task. The output of the sign reader must provide a well-defined perceptual-level input to autonomous planning resources. Provide an initial demonstration to validate the approach.

PHASE II: Augment and refine the sign reading algorithms. Implement the representational and reasoning infrastructure, and develop and populate a world knowledge base about signboards including how they are situated and what they "mean." This will require the perception (and representation) of other environmental features that create the environmental context in which the signs are situated. Demonstrate the system in widely varying environmental conditions (including real roadway traffic) and experimentally validate the performance level achieved.

PHASE III DUAL USE APPLICATIONS: This technology would be a valuable complement to GPS-based navigation systems, providing superior positional resolution and working in the absence of GPS satellite coverage. Road sign perception will enrich dynamic environmental maps with positions acquired by this system and subsequently assist with the precision of current vehicle position information. This vision-based system could be incorporated into intelligent vehicles without requiring new traffic infrastructure devices and could be adapted to operate in different countries. Autonomous robotic systems used for search and rescue, logistics and motor pools, and construction would benefit from this perception-based decision making capability. It is also relevant to manned vehicles, in the context of Intelligent Transportation Systems and Intelligent Vehicles for improved road safety.

KEYWORDS: Perception, Vision-Based Decision Making, Traffic and Road Sign Recognition, Robots, Navigation, Autonomous Behaviors.

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DARPA SB021-014 TITLE: ElectronicTextiles

KEY TECHNOLOGY AREA: Sensors, Electronics and Battlespace Environment

OBJECTIVE: To develop cost-effective mechanisms to interconnect devices to electrically conductive fibers woven into textile fabrics and to form a functional, large-area, flexible, conformable circuit.

DESCRIPTION: Fabrics (textiles) are formed as the result of weaving, knitting, or braiding individual fibers to provide a large-area, flexible product that can be used for a wide variety of purposes (clothing, sheets, wall coverings, rugs, tarps, etc.). The 2-D weaving process involves the overlapping of fibers and produces regular patterns typical of those in an x-y grid. Electrically conducting fibers that incorporate an insulating layer can be fabricated and used as the feedstock for the textile process. The manufacturing tools, processes, and materials employed by the textile industry offer an infrastructure upon which electronic circuits can be fabricated. This effort focuses upon the development of functional but simple circuits on fabrics not greater than one square foot in area. The emphasis is not upon high-performance (high-speed) but upon the feasibility of implementing electronic circuitry on fabrics and exploiting the advantages of textile manufacturing to achieve large-area, flexible, conformable circuitry.

PHASE I: The focus of Phase I will be to create a circuit design that is compatible with textile manufacturing processes and materials. The objective of this phase is to examine alternative methods of attaching electronic components to the fabric and methods to electrically interconnect those components into a functional circuit. Relatively simple circuits such as a memory module or small acoustic array are acceptable. The Phase I deliverable will be a circuit design along with a technical description of attachment/interconnection schemes and a plan describing how the circuit will be fabricated and tested.

PHASE II: The focus of Phase II will be to fabricate a functional circuit based upon the design completed in Phase I. The circuit will be tested in accordance with the Phase I test plan to determine electrical and mechanical integrity and circuit performance.

PHASE III DUAL USE APPLICATIONS: Candidate applications for electronic textiles lie in the domain where large area, flexibility, and conformability are of greater importance than high-speed performance or packaging density. Applications of this technology are in smart clothes, active surfaces (automobiles, airplanes boats, etc.), intelligent living spaces, medical (physiological) monitoring, etc.

KEYWORDS: Electronic Components, Packaging, Textiles, Fibers, Fabric.

DARPA SB021-015 TITLE: Three Dimensional Micro-Fluidics

KEY TECHNOLOGY AREA: Biomedical

OBJECTIVE: Develop integrated, complex micro fluidic flow devices that advance the rapid, multiplexed sample processing of blood or environmental samples and/or identification of biological pathogens by extending the fluidic channels into a third dimension.

DESCRIPTION: Research and development of innovative solutions towards the fabrication of highly integrated micro fluidic devices on smaller footprints that are capable of very large-scale integration (VLSI) with micro fluidic, optoelectronic, electronic components on a chip-scale. These efforts apply current micro fluidic technologies; many of which are under development in the current Biofluidic Chips (BioFlips) Program (www.darpa.mil, Microsystems Technology Technical Office, R&D areas), and advance multiplexed sample processing and sample identification functions through three dimensional micro fluidics utilizing shortened fluidic pathways. The rapid sorting of cells, bacteria, viruses and/or molecules and/or their detection at the molecular level is strongly encouraged. On the fabrication side, platforms (such as those presented by soft lithographic techniques) for low cost devices for the homogeneous or heterogeneous integration of micro fluidic components that may be readily assembled into systems capable of various biological sample-processing functions are sought. Also strongly encouraged is the development of reusable, reconfigurable micro fluidic devices. Additional efforts in device technology include the advancement of methods for multiplexed signal amplification, in-channel direct detection, integrated, compact addressable optical manipulation or detection techniques, schemes for assembling biological processing and detection components through integrated micro fluidic connections, novel micro-pumps/valves and schemes for multiplexing arrays of pumps/valves.

PHASE I: Develop proof of concept design and comparison with state-of-the-art technologies.

PHASE II: Development of a compact, integrated, three-dimensional micro fluidic device capable of demonstrating rapid sample preparation, cell sorting and/or highly sensitive assays.

PHASE III DUAL USE APPLICATIONS: Micro fluidic technologies developed under this topic will be the basis for embedded chips on soldiers to monitor physiological signatures for early detection of bio-warfare agent exposure, triage of bio-events and vital signs monitoring. In addition, such chips may also be utilized in biological sample processing for water quality, air

monitoring, on-site testing of blood supply/donor and rapid identification of bio-warfare agents. Commercial applications are most relevant in cell screening, drug discovery, gene expression and diagnostics.

KEYWORDS: Micro Fluidics, BioMEMS, Sample Preparation, Lab-on-a-Chip.

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DARPA SB021-016 TITLE: Design Tools for Integrated 3-Dimensional Electronic Circuits

KEY TECHNOLOGY AREA: Sensors, Electronics and Battlespace Environment

OBJECTIVE: Development and demonstration of Computer Aided Design (CAD) tools for integrated 3-dimensional (3-D) electronic circuits.

DESCRIPTION: Three dimensional integration offers the potential to significantly improve circuit performance by reducing interconnect lengths and delays that are becoming critical bottlenecks as device sizes continue to shrink and integration densities and chip areas continue to increase. Three-dimensional circuits also offer the promise of integrating disparate technologies within a single block, i.e., memory and logic circuits, radio frequency (RF) and mixed signal components, optoelectronic devices, etc. Although 3-D integration has been the subject of several research efforts, significant challenges associated with efficient circuit design and operation have hampered the adoption and further development of this technology. One critical challenge is the heat dissipation from vertically stacked multiple layers of active devices in a 3-D block. Innovative research into 3-D circuit architectures and advanced heat sink technologies are needed to overcome this difficulty. Another critical challenge is the development of novel design tools to assess three-dimensional placement and routing of the circuit, and the ability to design and synthesize 3-dimensional circuit architectures. DARPA is interested in exploring the feasibility of developing a new generation of CAD tools to enable the design of integrated three-dimensional electronic circuits.

PHASE I: Develop methodologies to analyze and assess coupled electrical and thermal performance of electronic circuits. Develop novel circuit placement and routing algorithms that enable exploration and optimization of 3-D circuit architectures for a given specification. Demonstrate feasibility of designing 3-dimensional circuit architectures that have improved performance, i.e., order of magnitude improvement in interconnect latency with acceptable thermal performance. The Phase I effort will also develop a plan to interface the 3-D design tools with either new or existing design environments in order to validate and demonstrate the methodology in Phase II.

PHASE II: Further develop and extend the tools and concepts developed in Phase I to demonstrate the synthesis and optimization of 3-D circuit architectures. Develop and implement model libraries for 3-D circuit components and sub-blocks/circuits based on coupled thermal/electrical performance characteristics. Develop tools for the coupled optimization of parameters such as integration density, cross talk, interconnect latency and thermal management. The Phase II effort will also implement the plan (developed in Phase I) to interface the 3-D tools with design environments for electronic circuits. Perform verification and validation studies to demonstrate the capabilities of the 3-D design tools. Complete documentation of the 3-D design methodologies, test cases and the test results must be delivered upon completion of the contract.

PHASE III DUAL USE APPLICATIONS: This effort will form the groundwork for advanced CAD tools for routine analysis and design of integrated 3-dimensional electronic circuits. These developments will enable the design of a new generation of integrated circuits with superior interconnect performance, optimized chip areas as well as the ability to integrate mixed technologies in a single block. This will have a significant impact on the design of mixed signal (digital/analog/RF) systems and Systems-on-a-Chip (SoC). Three-dimensional circuit integration will enable novel high performance sensing, communication and processing systems for current and future military requirements. It will also impact commercial applications such as wireless communication systems, optical/optoelectronic devices and systems, etc.

KEYWORDS: Three-Dimensional Integration, Integrated Circuits, Interconnect Latency, Computer-Aided Design, Thermal Management, Mixed Signal Systems.

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DARPA SB021-017 TITLE: Wide Bandgap Semiconductor (eg., SiC, GaN) Front-End Electronics for Wide Dynamic Range Analog/Digital Converters

KEY TECHNOLOGY AREA: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop wide bandgap semiconductor devices and/or building block circuits, which can be incorporated into wide dynamic range analog/digital converters.

DESCRIPTION: A broad range of defense radar, communications, electronic warfare (EW) and signals intelligence (SIGINT) systems, whether they are land, ship, airborne, space, or handheld could have greatly increased performance if wider dynamic range analog/digital converters (ADC's) were available. Defense analog-to-digital converter (ADC) performance requirements (dynamic range or resolution, sampling rate, center frequency, input analog bandwidth, noise figure, tunability) often **far exceed** the capability of commercial ADC's. Wireless applications are the major commercial driver for ADC development and silicon is the semiconductor material of choice because it provides adequate performance, can be densely integrated with (silicon-based) digital electronics, and is relatively low cost. Although both scaled complementary metal oxide semiconductor (CMOS) and silicon germanium circuits can achieve very high speeds, for many ANALOG OR MIXED-SIGNAL applications such as high resolution ADC's suffer from a major limitation, relatively low breakdown voltage. This problem will get worse, ie., breakdown voltage will continue to decrease, as silicon-based devices are further scaled to achieve the speeds desired in future very fast DIGITAL circuits. Wide bandgap semiconductor (WBS) devices offer the possibility of high speed together with very high breakdown voltage. The initial impetus in WBS circuit research has been to develop high efficiency power amplifiers. By contrast the emphasis here is to investigate the potential of WBS for devices and circuits that are high speed, linear, low noise, wide dynamic range, and can be densely integrated with other semiconductor circuits into analog/digital or digital/analog converters. It is expected that for optimal performance a wide dynamic range converter will contain devices and circuits fabricated from different semiconductor technologies. The question here is what unique contribution can WBS devices and circuits make. The application of the developed circuits for both baseband and bandpass converters are of interest. Examples of important converter goals are ADC's with 16 effective bits, 100 MHz bandwidth and 12 effective bits, several GHz bandwidth.

PHASE I: Devise a feasibility plan for WBS devices which offer potential for significantly improving the dynamic range of very high performance data converters.

PHASE II: Design, fabricate, evaluate, and deliver WBS wide dynamic range devices and/or circuits.

PHASE III DUAL USE APPLICATIONS: The technology developed here will eventually be needed in commercial applications such as telecommunications in high interference environments.

KEYWORDS: Analog/Digital Converters, Digital/Analog Converters, Mixed-Signal Circuits, Wide Dynamic Range Data Converters, Wide Bandgap Semiconductor Devices, Wide Bandgap Semiconductor Integrated Circuits.

DARPA SB021-018 TITLE: VHF/UHF Endo-Clutter SAR Fiducial Marker

ITAR Restrictions Apply

KEY TECHNOLOGY AREA: Sensors, Electronics and Battlespace Environment

OBJECTIVE: Develop a ground-based fiducial marker that can be deployed within foliated areas to aid in the registration of high-resolution, multiple-polarization VHF (very high frequency) and UHF (ultra-high frequency) Synthetic Aperture Radar (SAR) images.

DESCRIPTION: A number of SAR applications (e.g. multi-band fusion, change detection, interferometry and tomography [1]) require very accurate spatial registration of multiple-frequency and/or multiple-pass images. The images can be formed during a single pass of a platform carrying multiple sensors, during multiple imaging passes, or both. Additionally, as in the case of tomography, the radar passes can be made at significantly different aircraft heading angles and/or altitudes. In the extreme case, the images to be registered could view the target area over 360-degrees of azimuth aspect angles and from many different elevation angles. The registration process can be significantly enhanced if accurate "tie points" are available in the SAR images. Surveyed corner reflectors are sometimes placed in the areas being imaged to serve as fiducial markers to aid in the registration process. However, corner reflectors are only effective over a relatively small angular extent and must be very large to have a significant radar cross section at low radar transmit frequencies. DARPA desires to develop a ground-based fiducial marker (either an active or a passive device) that can be placed in an area being imaged to support the automated registration of multiple VHF and UHF SAR images. The marker must support simultaneous imaging at both VHF and UHF, and must be robust to significant differences in grazing angle and sensor heading. Also, the fiducial marker must operate in forested regions as well as in open terrain. The technologies that are used to develop this marker must be compatible with future military and civilian

utilizations. DARPA is interested in testing the fiducial marker using the Foliage Penetration (FOPEN) SAR Advanced Technology Demonstration (ATD) system [2]. The FOPEN ATD is dual-band radar, containing a VHF (nominally 25 to 52 MHz) SAR with horizontal polarization and a UHF (nominally 235 to 445 MHz) SAR with simultaneous horizontal, vertical and cross polarization channels. Linear FM (frequency modulation) waveforms are used in both radars. The pulse length varies a function of range and the pulse repetition frequency (PRF) varies a function of the aircraft velocity.

Export Control Warning: ITAR restrictions apply to sensor information that is not provided in Reference [2], as well as to SAR image data.

PHASE I: Conceive an experimental version of the VHF/UHF SAR fiducial marker. Identify risk items that must be demonstrated (e.g. feedback / self-jamming, false triggering, RFI (radio frequency interference), omni-directional coverage)) during the marker testing. Identify any minor modifications that could be made to the SAR ATD system to enhance the performance of the fiducial marker.

PHASE II: Fabricate and demonstrate one or more prototype versions of the VHF/UHF SAR fiducial marker. (Hand placement, field maintenance, etc. are permissible during the demonstration of the experimental version.) Develop concepts for deploying such a fiducial marker to support both commercial and military SAR operations.

PHASE III DUAL USE APPLICATIONS: The fiducial marker will provide a major benefit to both military [3] and commercial [4, 5] VHF/UHF SAR data processing techniques that require multiple image registration. These include the generation of digital elevation models (DEMS), classification of terrain cover for land use evaluation and detection of concealed targets.

KEYWORDS: SAR, Synthetic Aperture Radar, Image Registration, Fiducial Marker.

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4. Wheeler, K. and Hensley, S., " The GEOSAR Airborne Mapping System", *Proceedings of the IEEE 2000 National Radar Conference*, Alexandria VA, May 2000.
5. Hellsten, H., et al, "Development of VHF CARABAS II SAR," *Proceedings of the SPIE*, Vol. 2747, (Conference on Radar Sensor Technology), Orlando FL, April 1996.

DARPA SB021-019 TITLE: Airplane Optimal Periodic Flight Control

KEY TECHNOLOGY AREA: Air Platforms; Weapons

OBJECTIVE: Develop and demonstrate optimal periodic flight control algorithms that increase aircraft range performance and endurance performance.

DESCRIPTION: Traditional steady-state airplane cruise, where the vehicle flies at a constant altitude and a constant velocity, is not generally optimal 1. It has been discovered that non-steady type cruise flight profiles will produce more optimal performance. This type of cruise consists of a flight path where the control and state variables behave in a periodic manner. As a result, the trajectory of the aircraft is no longer rectilinear but show a periodic behavior consisting of repeated cycles. Studies have shown that significant range performance and endurance performance can be achieved with optimal periodic trajectories in the subsonic, supersonic and hypersonic flight regimes 2, 3. In the subsonic flight regime, range performance could be enhanced by about 20% and endurance could be enhanced by greater then 50%. The above-mentioned studies have assumed a still atmosphere; that is, real world effect of wind, wind shear, and rising and descending air mass are neglected. In fact, studies 4, 5 have shown that energy in the air can be harvested with periodic flight paths and used to extend a vehicle's range and endurance performance. For aircraft that are flying in the low subsonic regime, this flight technique could greatly increase performance many fold. A single cycle of a periodic flight path can be conceptually divided into two phases. In the first phase, the vehicle thrust is at its maximum. Maximum thrust is greater then the vehicle drag which results in an increase in the vehicle's energy. The energy is invested into the vehicle's altitude and velocity. The second phase, with thrust at a minimum, takes the energy achieved in the first phase and uses it to gain as much range as possible. Better overall performance is achieved because energy added per fuel consumed during phase 1 of the periodic trajectory is much higher than is possible for steady state cruise. There are a number of military and commercial missions that can take advantage of optimal periodic control. In many cases, a physical change to the airplane is not necessary, only a change in the flight path flown. The concept of periodic cruise (Dynamic Soaring) is indeed an idea that has been around for more than 30 years; however, it has never truly been evaluated in practice. This SBIR attempts to conduct a sequence of flight tests at subsonic speeds to validate this idea on a fleet of unmanned air vehicles

(UAV's). UAVs are chosen because they represent future battlefield platforms for reconnaissance and delivery of weapons. More importantly, it is only recently that UAVs have reached a level maturity where automated non-conventional flights trajectories can be programmed to do a variety of functions. One of the key issues associated in using UAVs is long-range endurance. This technique of dynamic soaring may enhance the endurance of these vehicles that fly at subsonic, supersonic and hypersonic speeds. Again, from academic studies it appears that the greatest benefit may be at hypersonic speeds, however, validation in this flight regime is not economic nor does the technology fully exist to evaluate this concept. The risk associated with this project is in the level of automated coordination of vehicle engine parameters, control surface deflections and flight control to achieve optimal fuel-efficient flight. Hence the ability to demonstrate this technology would be critical evidence that would support future operation of high-speed vehicles including missiles, and long range bombers that may be programmed to fly periodic trajectories to carry more payloads for greater distances. This topic seeks to develop automatic flight control algorithms to enable airplanes to take advantage of this type of flight control. A successful proposal will develop a strategy for sensing various technical parameters, (i.e.: wind, shear, air data, loads, engine, etc.) and use this data in a flight control algorithm to achieve a particular performance objective. Reasonable performance objectives could be, but are not limited to, range, speed/range, endurance, mean speed, total heat load, etc. Since the objective of the topic is to develop a practical flight control system, reasonable flight constraints must be considered as part of the demonstrated concept. It is also reasonable for a successful proposal to identify and demonstrate strategies for applying periodic flight control to aircraft designed to optimize the advantages of non-steady state flight rather than to design along traditional lines.

PHASE I: Characterize the advantage of optimal periodic flight control and perform a structured flight experiment to demonstrate proof of concept.

PHASE II: Develop and flight test flight control algorithms to implement optimal periodic flight control into existing manned and unmanned aircraft.

PHASE III DUAL USE APPLICATIONS: There are many UAV military missions that wish to maximize vehicle endurance. There are also many manned aircraft missions that require maximum loiter capability. A periodic flight control law would give these aircraft an immediate gain in performance. There are also many proposed commercial and government agency missions that need a slow subsonic vehicle to loiter for long periods. This technology would have direct application.

KEYWORDS: Reduced Fuel Consumption, Optimal Cyclic Cruise, Optimal Cruise, Periodic Flight, Optimal Periodic Flight, Periodic Flight Control, Improving Airplane Performance.

REFERENCES:

1. Speyer, J. L., "On the Fuel Optimality of Cruise," Journal of Aircraft, Vol. 10, Dec. 1973, pp. 763-765.
2. Sachs, G., and Christodoulou, T., "Reducing Fuel Consumption of Subsonic Aircraft by Optimal Cyclic Cruise," Journal of Aircraft, Vol. 24, No. 9, pp.616-622.
3. Speyer, J. L., "Periodic Optimal Flight," Journal of Guidance, Control, and Dynamics, Vol. 19, No. 4, pp. 745-755.
4. Reynolds, O., "The Soaring of Birds," Nature, Vol. XXVII, p. 534.
5. Wilson, J. A., "Sweeping Flight and Soaring by Albatrosses," Nature, Vol. 257, p. 307.

DARPA SB021-020 TITLE: <u>Water-Based Thrusters for Space Propulsion</u>

KEY TECHNOLOGY AREA: Space Platforms

OBJECTIVE: Design, build, and test innovative space satellite thrusters using water or its constituent gases as a fuel (propellant) and having high specific thrust.

DESCRIPTION: Space satellites maneuver to maintain orbit and to move from one orbit to another. It is envisioned that future military space satellites will be required to do far more maneuvering than current satellites, that the propellant required for maneuvering will be treated as a consumable item to be replaced several times during the lifetime of a satellite, and that water will be the only propellant for the thrusters. The water will be used as a propellant in two ways, directly in liquid form and converted to hydrogen and oxygen gases. Ongoing research (Ref. 1) will develop a regenerative fuel cell system to handle the water and convert it to the constituent gases. Several kinds of thrusters have been demonstrated (Ref. 2), some of which may work on water. The objective of this topic is to develop innovative thrusters specifically for use with water or its constituent gases as a propellant. Thrusters are needed for all kinds of maneuvering. Electrically powered thrusters with very high specific impulse (thousands of seconds) will be applied to major changes to orbit. Thrusters with reduced electric power requirements (< 1 Watt / mN) or that burn the hydrogen and oxygen will be applied for more rapid maneuvering. Thrusters with intermediate performance levels are also required. Since thrusters operate at high temperatures, lifetime is an important issue.

PHASE I: Identify design requirements for the thruster, model its performance, show through analysis a usefully high level of performance, perform critical experiments on the functionality of the thruster using water or its constituent gases, and identify the key issues for demonstration in Phase II.

PHASE II: Establish in detail the design requirements and the performance model, build and test critical components of the thruster, build and demonstrate a working thruster, and show that it can operate reliably over a long lifetime.

PHASE III DUAL USE APPLICATIONS: The military application of water-based thrusters is to satellites that must maneuver frequently or will have a long lifetime during which they will be refueled and serviced. Frequent maneuvering may be required for tactical surveillance of changing threats. The commercial world has the analogous need to change areas of coverage, for example, in response to news events. Also, it may be practical to maneuver a satellite into place to cover for a failing geosynchronous satellite.

KEYWORDS: Space Propulsion, Satellites, Thrusters, Electric Thrusters.

REFERENCES:

1. http://www.darpa.mil/TTO/wbps/baa01-23.html
2. http://eis.jpl.nasa.gov/sec353/apc/index.html

DARPA SB021-021 TITLE: Tracklet Fusion for strategic GMTI

KEY TECHNOLOGY AREA: Sensors, Electronics and Battlespace Environment

OBJECTIVE: Develop methods for associating short duration track files (tracklets) in order to maintain situational awareness on high priority targets, such as transportable erector launchers (TELs). For non-defense scenarios might consist of vehicles as part of the smart highway initiative, animals in wildlife tracking, or air vehicles in collision avoidance.

DESCRIPTION: Ground Moving Target Indication (GMTI) holds the promise of providing dominant situational awareness on specified targets of interest. In a military context these would be for maneuver warfare, as well as indications and warning during preconflict periods. The presence of terrain obscuration and foliage, as well as micro obscuration (buildings, tunnels, overpasses), combined with target fluctuation generally leads to less than ideal track duration. For strategic GMTI, whereby one seeks to maintain overall situational awareness as opposed to targeting movers directly, there is a potential solution: mainly to associate tracklets to obtain a fused data product. As an example application suppose one seeks to determine the presence of TELs in a given region. One might obtain tracklets, which in isolation have a probability of corresponding to a TEL, which is suggestive but not conclusive (say 80% confidence). If one can associate tracklets based on behavior, terrain, and range profiles one can boost the confidence through a process analogous to incoherent gain in radar dwells. Note that the intent of tracklet fusion is not maximizing track duration but rather tracklet information. This might suggest a different operating point in the tracker is desired; say longer dwells, higher bandwidth, or possibly tighter association windows. These will disallow long track duration (for fixed area rate) but may allow better post track fusion. In addition synthetic aperture radar (SAR) imaging may be desired in an interweave configuration. While the above discussion motivates tracklet fusion in the warfighter context the ability to associate track segments through significant gaps have dual use applications as outlined below.

PHASE I: Develop a theory of tracklet fusion, and develop design tools to determine optimal track parameters. Construct a simulation testbed to evaluate the situational awareness achievable in tracklet fusion using realistic foliage and terrain obscuration models. Include models for high-resolution range profiling, including confusion matrices as a function of bandwidth and signal-to-noise ratio (SNR). Develop a track fusion software testbed and determine the size of a reference area one can "cleanse" for high value targets using several radar models, e.g. Jstars, Global Hawk, and Discoverer II.

PHASE II: Apply the track fusion software to ground truthed data testbeds. Determine robustness to, and the degree of degradation from, clutter discretes, geolocation biases, etc.

PHASE III DUAL USE APPLICATIONS: Commercial applications include law enforcement applications for tracking noncompliant targets.

KEYWORDS: Ground Moving Target Indication (GMTI), SAR, Synthetic Aperture Radar, Dominant Situational Awareness, High Resolution Range Profiling, Feature Aided Tracking, Data Fusion.

BALLISTIC MISSILE DEFENSE ORGANIZATION (BMDO)
SMALL BUSINESS INNOVATION RESEARCH PROGRAM (SBIR)

INTRODUCTION

The BMDO SBIR program is implemented, administrated and managed by the BMDO Office of the Chief Scientist. The BMDO SBIR Program Manager is Jeff Bond. If you have any questions regarding the administration of the BMDO SBIR program please call 1-800-WIN-BMDO. Additional information on the BMDO SBIR Program can be found on the BMDO SBIR home page at http://www.winbmdo.com. Information regarding the Ballistic Missile Defense Organization's mission and programs can be found at http://www.acq.osd.mil/bmdo/bmdolink/html/.

GENERAL INFORMATION

The fundamental objective of the Ballistic Missile Defense (BMD) program is to develop the capability to defend the forces and territories of the United States, its Allies, and friends against all classes of ballistic missile threats. The goal of the BMD System (BMDS) is a layered defense that provides multiple engagement opportunities along the entire flight path of a ballistic missile. We will explore and demonstrate kinetic and directed energy kill mechanisms for potential sea-, ground-, air-, and space-based operations to engage threat missiles in the boost, midcourse, and terminal phases of flight. In parallel, sensor suites and battle management and command and control (BMC2) will be developed to form the backbone of the BMD System.

The boost phase is that part of flight when the ballistic missile's rocket motors are ignited and propel the entire missile system towards space. It lasts roughly 3 to 5 minutes for a long-range missile and as little as 1 to 2 minutes for a short-range missile. When the missile boosters are spent, the missile continues its ascent into what we call the midcourse part of flight (which lasts nominally 20 minutes for a long-range missile). In this stage of flight, a ballistic missile releases its payload warhead(s), submunitions, and/or penetration aids it carried into space. The missile enters what we call the terminal phase when the missile or the elements of its payload, for example, its warheads, reenter the atmosphere. This is a very short phase, lasting from a few minutes to less than a minute. There are opportunities and challenges to engage a threat missile in each of these phases.

The primary Terminal Defense Segment project is the Theater High Altitude Area Defense (THAAD) system. The mission of the THAAD System is to defend against short- and medium-range ballistic missiles at significant distances from the intended target and at high altitudes. This evolutionary program is structured to demonstrate capability in 2004, with planned improvements based on upgraded seekers, ground support equipment, and discrimination software. Current efforts are addressing component and system performance, producibility, and supportability.

The Midcourse Defense Segment program is divided into Ground-based Midcourse Systems and Sea-Based Midcourse Systems. The Ground-based Midcourse System has three objectives: 1) to develop and demonstrate an integrated system capable of countering known and expected threats; 2) to provide an integrated test bed that provides realistic tests and reliable data for further system development; and 3) to create a development path allowing for an early capability based on success in testing. The Sea-based Midcourse System is intended to intercept hostile missiles in the ascent phase of midcourse flight, which when accompanied by ground-based system, provides a complete midcourse layer. The Sea-based Midcourse System will build upon technologies in the existing Aegis Weapon System and the Standard Missile infrastructures and will be used against short and medium range threats.

The mission of the Boost Defense Segment is to define and develop boost phase intercept missile defense capabilities. To engage ballistic missiles in this phase, quick reaction times, high confidence decision-making, and multiple engagement capabilities are needed. The development of higher power lasers and faster interceptor capabilities are required. There are four principal objectives for the Boost Defense Segment. First, it will seek to demonstrate and make available the Airborne Laser (ABL). Second, it will define and evolve space-based and sea-based kinetic energy Boost Phase Intercept concepts. Third, this segment will execute a proof-of-concept Space-Based Interceptor Experiment (SBX). Fourth, it will continue Space-Based Laser (SBL) risk reduction on a path to a

proof-of-concept SBL Integrated Flight Experiment (SBL-IFX). Kinetic boost phase intercept is a challenge because the threat missile must be detected and confirmed within a few seconds of launch. It then becomes a race between an accelerating ballistic missile and the interceptor in which the threat missile has had a head start. Another technical challenge is designing a kill vehicle that can detect and track the target following missile-staging events and then impact the missile in the presence of a brilliant plume. We are considering a sea-based boost activity to develop a high-speed, high-acceleration booster coupled with a boost kill vehicle.

A satellite system intended to support missile defense operations is the Space-Based Infra-Red Sensor (SBIRS). SBIRS-Low, in conjunction with SBIRS-High (developed by the Air Force), form the SBIRS system, which will consist of satellites in Geosynchronous Orbits (GEO), Highly Elliptical Orbits (HEO) and Low Earth Orbits (LEO) and an integrated centralized ground station serving all SBIRS space elements and Defense Support Program (DSP) satellites. The focus of BMDO is on SBIRS-Low, which will incorporate new technologies to enhance detection; improve reporting of Intercontinental Ballistic Missile (ICBM), Sea-Launched Ballistic Missile (SLBM) and tactical ballistic missiles; and provide critical mid-course tracking and discrimination data for BMD.

Finally, the Science and Technology (S&T) Program will develop components, subsystems and new concepts needed to keep pace with the evolving ballistic missile threat. The primary focus of the Technology Segment is the development of sensors and weapons for future platforms that can complement today's missile defense capabilities. Specific projects include the development of a doppler radar to be used in a missile seeker, the demonstration of active and interactive midcourse discrimination techniques, the design and development of miniature kill vehicles for boost and midcourse application, and the development and/or testing of space relay mirrors for laser tracking systems. In addition to thrust area projects, investments are made in technology at the component level to improve the state-of-the-art in radars, infrared sensors, lasers, optics, propulsion, wide band gap materials, and photonic devices.

The intent of BMDO's Small Business Innovation Research Program is to seek out the most innovative technology that might improve the performance or reduce the cost of ongoing development programs in BMD. Proposing companies need not know specific details or requirements of specific BMDO systems; but in order for them to propose technology applications that may be relevant to ballistic missile defense programs, it will helpful for them to understand related research and development goals or specific technology needs.

The BMDO goal in Phase I is to pursue as many innovative research concepts and approaches as possible offering potential military as well as non-military applications as the result of commercialization for Government or private sector markets. The BMDO goal in Phase II is to develop those technologies that hold the most promise, considering feasibility, relevance, and transition opportunity. A strong indication of that promise is an identified sponsor for the proposed project (from government or industry) who will apply the demonstrated technology in a product to meet BMD needs.

PHASE I GUIDELINES

BMDO intends for Phase I to be only an examination of the merit of the concept or technology that still involves technical risk, with a cost under $70,000. Although proposed cost will not affect selection for negotiation, contracting may be delayed if BMDO determines that award should be made for less than the proposed cost. Do not submit the same proposal, or variations thereof, to more than one BMDO topic area. If BMDO decides that a proposal is relevant to another topic, the proposal will be passed on to reviewers in that topic area. It is strongly suggested that you do not use the title of the BMDO SBIR Topic as the title of your Phase I or Phase II proposal. Preferably, titles should reflect the innovativeness or other value added of your proposal in responding to a specific BMD need encompassed by the Topic.

Proposal Submission

Proposers are required to register and submit their entire proposal through the DoD Electronic Submission Website (http://www.dodsbir.net/submission). As instructed on the website, the proposal should include a BMDO Proposal Cover Sheet, Cost Proposal, and Company Commercialization Report. Proposals shall be uploaded via the DoD Electronic Submission Website by the solicitation close date and time. Proposals sent by other means will not be

accepted; hard copy submissions of Phase I proposals will no longer be accepted. Note, however, that a signed original of the Cover Sheet must be submitted by mail to the following address:

Ballistic Missile Defense Organization
ATTN: ST/SBIR (Bond)
7100 Defense Pentagon
Washington, DC 20301-7100

Proposals and signed Cover Sheets received after the closing date will not be processed.

PHASE II GUIDELINES

Phase II is the demonstration of the technology that was found feasible in Phase I. BMDO selects awardees for Phase II developments through two competitive processes: a routine competition among Phase I awardees that have been invited to submit Phase II proposals; and a Fast Track competition for Phase I awardees that are able to propose independent funding as part of their Phase II application.

The BMDO SBIR PM or one of BMDO's executing agents for SBIR contracts will inform Phase I participants of their invitation to submit a Phase II proposal. Fast Track submissions do not require an invitation; see DoD's Fast Track guidelines. Phase II proposals may be submitted for an amount normally not to exceed $750,000. Companies may, however, identify requirements with justification for amounts in excess of $750,000. The preferred contract type for BMDO Phase II awards is Firm-Fixed Price.

Proposal Submission

If you have been invited to submit a Phase II proposal, please see the BMDO SBIR website http://www.winbmdo.com for further instructions. Starting this year, Phase II proposals for BMDO topics will be received and evaluated during one specific period of time. Companies who may choose not to submit Phase II proposals to meet the specific submission date are at liberty to submit proposals as part of the succeeding competition instead.

Phase I projects currently being performed will compete for Phase II awards according to the same guidelines as published at the time of the Phase I award. For SBIR projects selected under this solicitation, the following schedule will guide the submission and evaluation of Phase II proposals:

Phase II Key Dates

October 1-October 18, 2002: Submission of Proposals
October 21-November 22, 2002: Evaluation of Proposals
December 2002: First awards

By conducting two competitions annually and conducting evaluations on this expedited basis, BMDO expects to minimize lag times between completion of Phase I efforts and award of Phase II contracts. BMDO's executing agents may still exercise the prerogative, however, to arrange limited transitional funding to assist a successful Phase II competitor during the period prior to award of the Phase II contract.

SBIR Fast Track Program

The Fast Track Program is a Phase II option that is available for SBIR awardees that have attracted matching funds from a non-SBIR/non-STTR government program or an outside investor for the proposed Phase II SBIR effort. In preceding years, BMDO offered a tailored Fast Track process (called "Fastrack"). That process will no longer be followed, and BMDO instead will participate in the DoD Fast Track program, as explained in the DoD solicitation.

SBIR Phase II Enhancement Policy

To encourage the transition of SBIR research into BMDO acquisition programs, BMDO has implemented a Phase II Enhancement Policy. Under this policy, BMDO will allow extension of an existing Phase II contract for up to one year and will provide additional Phase II funding of up to $250,000, either: 1) as matching funds for non-SBIR BMDO funds directed to the Phase II contract; or 2) as transitional funding in anticipation of Phase III, based on a letter of intent to the BMDO SBIR PM from a BMDO acquisition program that will award a Phase III contract.

Ballistic Missile Defense Organization Topics

BMDO/02-001 - Directed Energy Concepts and Components

BMDO/02-002 - Kinetic Energy Kill Vehicles and Components

BMDO/02-003 - Sensors and Surveillance

BMDO/02-004 - Manufacturing Sciences and Technology/Unit Cost Reduction

BMDO/02-005 - Non-Nuclear Power Sources and Power Conditioning

BMDO/02-006 - Propulsion and Logistics Systems

BMDO/02-007 – Thermal Management

BMDO/02-008 - Survivability Technology

BMDO/02-009 – Lethality and Vulnerability

BMDO/02-010 – Computer Systems, Algorithms, and Models/Simulations

BMDO/02-011 – Photonics

BMDO/02-012 – Structural Materials, Concepts, Components and Composites

BMDO/02-013 – not used

BMDO/02-014 - Electronics and Superconductivity

BMDO/02-015 – not used

BMDO/02-016 - Surprises and Opportunities

BMDO FY02 SBIR TOPIC DESCRIPTIONS

BMDO 02-001 Directed Energy Concepts and Components

Introduction: As part of BMDO's charter to provide for defense against future missile threats, various programs are created to further validate potential technologies to design, develop, and deploy systems in support of various efforts. These new programs provide future decision-makers an option to greatly enhance the capabilities of future TMD and NMD systems. BMDO investigates directed energy technologies for both TMD and NMD applications. As such, a significant investment is made each year in the continued development of increasingly sophisticated systems which may eventually find their utilization in a ballistic missile technology program or major defense acquisition program. All areas of the electromagnetic spectrum provide potential avenues toward finding and disabling a ballistic missile in flight. Furthermore, components, sub-components, and piece part specifics are constantly under evaluation by the various TMD and NMD elements for replacement by the latest technology developments from industry. Current examples include the Space Based Laser and the Airborne Laser, and any other comparable sub-system, component, or subcomponent that can potentially support next generation developments. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

Description: BMDO seeks new, innovative and applied research toward advanced technology developments in the generation, propagation, and detection of directed energy in all forms and for the measurement of material properties of irradiated materials and structures. Dual-use systems under consideration include, but are not limited to, solid-state lasers (i.e. diode lasers), chemical lasers, excimer lasers, IR/Vis/UV lasers, agile lasers x-ray lasers, gamma-ray lasers, free electron lasers, particle beams, radio-frequency (RF) and millimeter wave (MMW) devices, and other unique hybrid approaches including explosively or electrically driven devices. Included herein are such topics as beam control, target acquisition, tracking and pointing, mirrors, beam propagation and steering, optics, antennas, conversion methods, quasi-phased matched non-linear optics (QPM NMO's), thermal management and heat removal for space, air, and ground based systems, countermeasures, coatings, deployable space optics, distributed apertures, and micro-optical-mechanical devices incorporating these aspects. Furthermore, any component or subcomponent that is utilized by any of these systems is of interest. Components, sub-components, or piece part specifics may be ground, air, or space based in their final application.

Phase I: Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

Phase II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

Successful Phase 3/Dual-Use Commercializers (Real-World Examples): Company A, whose advanced x-ray source is being utilized for waste sterilization, was sponsored from this topic. Company B utilized their tunable filters with the citrus industry and for military hyperspectral image applications.

DoD Key Technology Areas:

#1 --- Air Platforms
#5 --- Materials/Processes
#7 --- Sensors
#8 --- Electronics
#10--- Battlespace Environemnts
#11--- Space Platforms
#12 – Weapons
#13 – Nuclear Technology

BMDO 02-002 Kinetic Energy Kill Vehicles and Components

Introduction: Potential adversaries are expected to improve their ballistic missile systems and develop countermeasures to U.S. ballistic missile defense programs. The future designs of potential threat improvements that BMDO must address can not be determined explicitly. Broad-based kinetic energy interceptor technologies will potentially contribute to more than one program and possibly to more than one defense area. These kinetic energy weapons benefit from innovations offered in 1) discrimination, 2) sensors and seekers, 3) guidance, navigation and control, and 4) affordability. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

Description: Kinetic energy (KE) weapons candidates presently include a variety of ground and space based interceptor concepts. System elements include ground-based launchers, axial and divert motors/nozzles, smart projectile components, and endo/exoatmospheric guidance and control mechanisms. Technology challenges for KE systems include: high accuracy seekers; active seekers; ultra-compact laser radar; dual mode (radar/IR or ladar/IR) seekers; simultaneous multispectral focal plane arrays

(FPAs); wavelength-tunable FPAs; multicolor long wavelength FPAs; miniature hit-to-kill interceptors; finding the booster hardbody within a booster plume; high performance axial and divert propulsion sub-systems (especially very low mass divert and attitude control systems); miniature inertial navigation units; array signal processing; missile autopilots; long-range acquisition and multi-target tracking; distinguishing between lethal objects in the presence of decoys, chaff, aerosols, debris and other countermeasures (i.e. discrimination); electronic counter-countermeasure negation; lethality/miss distance; mitigating aero-optical effects and aero-thermal effects; optimal hit-to-kill homing navigation; shroud separation; IR window technology for hypervelocity endoatmospheric interceptors (including high temperature optical materials, self-compensating missile windows, low-cost AlON, and non-conventional window architectures); solid-state millimeter wave seekers; non-nuclear kill warhead performance; operations in a hostile environment; performance (including survivability of electronics); battle management; fire control; guidance and control; projectile launch survivability; and common among all systems reliability, producibility, safety (non-hazardous operation), maintainability, and lower-cost/lower-mass. New concepts and technologies that produce a much higher probability of hit-to-kill intercepts are required to support applications. Impact point selection technologies, instrumentation, concepts, and innovative methodologies are sought.

Phase I: Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

Phase II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

Successful Phase 3/Dual-Use Commercializers (Real-World Examples): Company C advanced the metal armature developments for military railgun efforts. Company D began with a bone implantation technology and international investments that resulted from divert motor rocket nozzles and have subsequently spun-out three other companies. Company E, with a market cap of $38M+, expanded with technology genesis from this topic to a dynamic frame seeker and chip-stacking developments. Company F supported ballistic missile defense efforts with their enhanced lethality kinetic energy projectile and has subsequently graduated out of the small business status, but continues to support the DoD in R&D efforts and was purchased by a Fortune 500 company Nov 1999.

DoD Key Technology Areas:

#1 --- Air Platforms
#5 --- Material/Processes
#10--- Space Platforms
#12--- Weapons

BMDO 02-003 Sensors and Surveillance

Introduction: BMDO investigates various sensor technologies for both TMD and NMD applications. As such, a significant investment is made each year in the continued development of increasingly robust and sophisticated sensor systems which may eventually find their utilization in a ballistic missile technology program or major defense acquisition program. All areas of the electromagnetic spectrum provide potential avenues toward finding and disabling a ballistic missile in flight. Furthermore, sensor systems, components, sub-components, and piece part specifics are constantly under evaluation by the various TMD and NMD elements for replacement by the latest technology developments from industry. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

Description: Sensors and their associated systems/sub-systems will function as the "eyes and ears" for ballistic missile defense applications, providing early warning of attack, target detection/classification/identification, target tracking, discrimination, and kill assessment. New and innovative approaches to these requirements using unconventional and innovative techniques are encouraged across a broad band of the electromagnetic spectrum, from radar to gamma rays. Passive, active, and interactive techniques for discriminating targets from backgrounds, debris, and decoys, in the presence of chaff, aerosols, electronic countermeasures, and other penetration aids are specifically sought. Sensor-related device technology is also needed. Examples of some of the technology specific areas are: higher efficiency and higher power radar transmit/receive modules (employing GaN technology); advanced digital array radars; efficient radar cooling; lightweight radar antennas; long-life cryogenic coolers (open and closed systems); cryogenic heat transfer; superconducting focal plane detector arrays (for both the IR and sub-mm spectral regions); next generation focal plane arrays (FPAs); signal and data processing algorithms (for both conventional focal planes and interferometric imaging systems- ultraspectral or hyper spectral imaging); low-power optical and sub-mm wave beam steering; range-doppler lidar and radar; passive focal plane imaging (long-wavelength infrared to ultra-violet; novel information processing to maximize resolution while minimizing detector element densities); large format focal plane arrays (from UV to VLWIR); high sensitivity uncooled FPAs; advanced very long wavelength FPAs; interferometry (both passive and with active illumination); QWIPs; quantum wires and quantum dots; strained-layer superlattice detectors; integrated multispectral FPAs, gamma-ray detection; neutron detection; intermediate power frequency agile lasers; lightweight compact efficient fixed frequency radiation sources for space-based ballistic missile defense applications (UV-sub-mm wave), new optics and optical materials. Entirely new and high-risk approaches are also sought. Please indicate the particular identifying letter your specific proposal/technology addresses:

BMDO/00-003**A** - Acoustic and Seismic
BMDO/00-003**B** - Radar and MMW
BMDO/00-003**C** - UV (<0.3 microns)
BMDO/00-003**D** - Visible (0.3 - 0.9 microns)
BMDO/00-003**E** - IR (>0.9 microns)
BMDO/00-003**F** - Gamma/X-Ray
BMDO/00-003**G** - Other

Phase I: Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

Phase II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

Successful Phase 3/Dual-Use Commercializers (Real-World Examples): Company G, with annual commercial sales of $15M+, is noted for its laser diode pumped Q-switched solid state laser products developed under this topic. Company H, with a market cap of $128M+, transferred its microwave based infrared detector and superconducting millimeter wave mixer technologies funded under this topic for a variety of cryogenic systems and products. Company OO's high power laser array transmitters are utilized on military and commercial satellites for communications. Company QQ, purchased by a larger company in Jun 00, received funding from this topic for their target surveillance, pointing, acquisition, and tracking sensors used by both military and civilian customers.

DoD Key Technology Areas:

#1 --- Air Platforms
#5 --- Material/Processes
#7 --- Sensors
#8 --- Electronics
#9 --- Battlespace Environments
#10--- Space Platforms
#11--- Human Systems
#12--- Weapons

BMDO 02-004 Manufacturing Sciences and Technology/Unit Cost Reduction

Introduction: BMDO continually investigates various diverse technologies for both TMD and NMD applications. As such, advanced technology demonstrations for affordability and advanced industrial practices to demonstrate the combination of both improved manufacturing process technologies and improved business methods are of interest. BMDO makes significant investments each year in the continued development of increasingly survivable, robust and sophisticated technology based systems. All areas of research, engineering, and manufacturing process technologies provide potential avenues toward finding and disabling a ballistic missile in flight. Furthermore, entire sensor systems, components, sub-components, or piece part specifics are constantly under evaluation by the various TMD and NMD elements for replacement by the latest technology developments from industry. Proposed efforts funded under this topic may encompass any specific manufacturing process technology at any level resulting in a unit cost reduction. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

Description: BMDO seeks drastically lower unit cost of all components through manufacturing revolutions and through leveraging of high volume production from commercial sales. This will result in an improvement in the affordability of new ballistic missile defense systems and the development of cost effective methods to sustain existing developments while impacting the next generation of acquisition systems. Affordability is a significant factor in all aspects of the total life-cycle consideration of any military program. Innovative approaches that will allow BMDO to economically acquire new technologies for the next generation of ballistic missile defense systems and maintain these systems while providing for their upgrades will make total life-cycle costs more affordable. Whereas all other BMDO SBIR topics seek first and foremost a revolution in the military capability of the technology, this topic seeks only a revolution in the reduction of unit cost specifics. BMDO seeks herein only projects that are too risky for ordinary capital investment by the private sector. The proposals must include and will be judged, in part, on an economic analysis of the expected market impact and the viability of the product proposed. Incremental advancements will receive very little consideration. Innovative manufacturing technologies which reduce the cost per unit, repair, or remanufacturing/reengineering of entire sensor systems, components, sub-components, or piece part specifics are under consideration.

Phase I: Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

Phase II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

Successful Phase 3/Dual-Use Commercializers (Real-World Examples): Company J, with a market cap of $42M+, founded its technology developments under this topic with low-cost radioisotope-powered voltaic cells for military applications and a wide variety of other commercially viable electronic material based applications to include quantum-wire lasers.

DoD Key Technology Areas:

#1 --- Air Platforms
#5 --- Materials/Processes
#10--- Space Platforms
#12--- Weapons

BMDO 02-005 Non-Nuclear Power Sources and Power Conditioning

Introduction: New and unique non-nuclear power sources and new materials and electronics that provide for the efficient use of power are under consideration by BMDO for both TMD and NMD applications. New technology could conceivably provide support to future systems, which may eventually find their utilization in a ballistic missile technology program or major defense acquisition program. All areas of power technology, except nuclear power, provide potential avenues toward finding and disabling a ballistic missile in flight. BMDO SBIR shall not consider any nuclear power source proposal. Furthermore, entire power source systems, components, sub-components, and piece part specifics are constantly under evaluation by the various component TMD and NMD elements for replacement by the latest technology developments from industry. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

Description: New technologies for producing, storing and conditioning power which provide substantial improvements in lower recurring cost, lower mass, and/or smaller size are sought for all ballistic missile defense applications. New concepts for compact power sources and power conditioning devices for transportable or mobile systems at 200 kW to 1 MW also need to have high efficiency, low signatures, and high reliability. Power generation, power storage, and power conditioning devices that operate at cryogenic temperatures for use in a new concept for all cryogenic systems are sought. Space assets' power sources in the 0.5 to 5 kW power range, including solar arrays and their photovoltaic cells, need to tolerate high natural radiation levels. Energy storage systems, rechargeable fuel cells, or novel battery technologies with cycle lifetimes of up to 40,000 cycles are sought that may be utilized in low earth orbit sensor satellites, airborne platforms, or ground based assets. Onboard power sources for interceptor missiles that are periodically testable, have a quick start-up capability, and produce high power for short time intervals (up to five minutes). Power conditioning systems and components for space assets should provide very high efficiency.

Phase I: Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

Phase II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

Successful Phase 3/Dual-Use Commercializers (Real-World Examples): Company K, with a market cap of $22+, has provided for commercializing its self-restoring fault current limiter after it was incorporated into military efforts. Company MM, with a market cap of $714M+, has developed new solar cells with increased efficiencies that are utilized by both military and civilian interest.

DoD Key Technology Areas:

#1 --- Air Platforms
#5 --- Material/Processes
#4 --- Ground and Sea Vehicles
#10--- Space Platforms
#12--- Weapons

BMDO 02-006 Propulsion and Logistics Systems

Introduction: BMDO is constantly investigating various propulsion technologies for both TMD and NMD applications. Significant investments are made each year in the continued development of increasingly robust and responsive systems which may eventually find their utilization in a ballistic missile technology program or major defense acquisition programs. All areas of propulsion technology provide potential avenues toward finding and disabling a ballistic missile in flight. Furthermore, entire propulsion systems, components, sub-components, and piece part specifics are constantly under evaluation by the various TMD and NMD elements for replacement by the latest technology developments from industry. Research or Research and Development efforts selected under this

topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

Description: In general, missile defense places unprecedented demands on all types of propulsion systems; for interceptors and satellites. Specifically, advancements are needed to achieve major reductions in the costs of placing and maintaining payloads in desired locations, high thrust boosters, non-toxic divert/attitude control systems. Approaches leading to techniques, methods, processes, and products in support of these propulsion and logistics objectives are sought. Advancements are needed in propulsion-related areas, e.g. extending storage time of cryogenic fluids (e.g. H_2 and Xe) and, reduction of contamination from effluents. Areas of interest include the entire spectrum of space transportation and support: efficient launch systems for small technological payloads to very large system payloads; assembly and control systems; expendable and recoverable components; improved structures and materials; and increased propulsion efficiency. Low mass or miniature interceptors require advances in divert (small thrusters) propulsion systems (either solid or liquid). Boost phase interceptors need high thrust (10-50 G), low-mass boosters. High acceleration, low-mass divert and attitude control systems (DACS) greater than 5Gs are sought. High temperature nozzles and other DACS components are of great interest. Less hazardous propellants for DACS are also needed.

Phase I: Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

Phase II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

Successful Phase 3/Dual-Use Commercializers (Real-World Examples): Company L developed a laser radar tracking technology that finds commercial use in laser eye-surgery applications, but was also investigated for tracking ballistic missiles in flight.

DoD Key Technology Areas:

#1 --- Air Platforms
#5 --- Material/Processes
#10--- Space Platforms
#12--- Weapons

BMDO 02-007 Thermal Management

Introduction: BMDO constantly investigates various thermal management and cooling technologies for both TMD and NMD applications. Therefore, a significant investment is made each year in the continued development of increasingly robust and sophisticated heating/cooling system technologies, which may eventually find their utilization in a ballistic missile technology program or major defense acquisition program. Furthermore, thermal management (heating and cooling) systems, components, sub-components, and piece part specifics are constantly under evaluation by the various TMD and NMD elements for replacement by the latest technology developments from industry. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

Description: Higher power levels of various ballistic missile defense assets must dissipate heat at state-of-the-art capabilities for waste thermal energy acquisition, transport, and dissipation to space. Technology advancements are required in thermal management for power generation systems, space platform payloads, heat pump radiators, laser diodes, diode fibers, slab lasers and an increased emphasis on all associated electronics including high power density wide bandgap devices. Some space platforms will require years of storage of large amounts of cryogen with minimum cryogenic loss and high cryogen delivery rates under condition of zero-g. As such, very long life space cryocoolers are of specific interest. Concepts, devices, and advanced technologies for all types of space-based power cycles are sought which can satisfy these projected ground/air/space platform requirements.

Phase I: Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

Phase II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

Successful Phase 3/Dual-Use Commercializers (Real-World Examples): Currently addressing electric vehicle technology applications for military and commercial interest, Company M got its initial start, and now with a market cap of $190M+, with active magnetic vibration isolation controls funded under this topic. Company SS developed a radiation hardened accelerometer that is used in the Safe-and-Arm device of the PAC-3 missile and by half of the automotive airbags in the U.S.

DoD Key Technology Areas:

#1 --- Air Platforms

#4 --- Ground and Sea Vehicles
#5 --- Materials/Processes
#10--- Space Platforms
#12--- Weapons

BMDO 02-008 Survivability Technology

Introduction: Missile defense elements must operate and survive against determined attacks. Threat actions can generate a reasonable set of hostile man-made environments before and during operations. Collateral environments and natural space environments (atomic oxygen, space radiation and micrometeorites/debris) provide additional technical challenges, which also affect civilian assets. Survivability engineering technology and survivability enhancement options are required to achieve a cost-effective, yet integrated solution to a dynamic and diverse set of hostile environments with a focus toward improving aspects of threat sensing, hardening, passive defense, and camouflage, concealment and deception (CCD). Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

Description: Sensor technologies enable the defense elements to detect nuclear events, laser and radio frequency weapon attacks, and to respond appropriately. Sensor technologies that can characterize the threat according to direction of attack, and spectral characteristics are currently under consideration. Technologies to enhance passive defense missile systems, ground/air/space assets, and support equipment are needed to operate against the threat support sensors, including radar, passive visible/IR sensors and seekers, and laser radar.

Passive hardening against the nuclear, laser, RF, ballistic and debris environments is specifically needed, in addition to novel radiation hardening technologies and approaches against the natural space environments. Sensor technologies and their associated systems, communications antennas (RF and laser), attitude sensors, solar power, propulsion, structure and thermal control are all directly exposed to nuclear, laser, RF and debris in addition to the natural space environments. Materials and component designs, which are intrinsically hard to these environments, and/or protective devices are needed, specifically with dual-use commercialization applications. A key ballistic missile defense area of consideration is seeker/sensor subsystems, the components of which (baffle materials, mirrors, optics, structures, focal plane arrays, read out electronics, and processing) must survive the laser, nuclear, IR, and natural environments, as well as, contamination from booster plumes and natural environments. Nuclear and laser hard concepts, materials, and devices for protection against unknown or agile lasers and rejection of RF energy. Structures and coatings providing appropriate thermal characteristics, stability under mechanical impulses and hardness to laser and RF radiation are needed. Processors, high-power ICs, and other electronic devices capable of operating in unique hostile environments presented by the strategic applications while retaining full functionality are desired. Long term space (commercial and government) applications are direct beneficiaries of these advanced technology developments. Countermeasures and integration of CCD technologies are particular useful to the operational forces and, in general, attempt to incorporate the latest military and commercial technologies to ensure an effective response to any advanced threat. Novel concepts and techniques that reduce the vulnerability of ballistic missile defense systems will increase the operational confidence level of dedicated assets. A new class of weapons technologies are evolving incorporating non-lethal methods. These have a broad range of applications as a survivability countermeasure or must themselves be countered to assure full operability. Non-lethal technology efforts in this area have dual-use applications.

Phase I: Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

Phase II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

Successful Phase 3/Dual-Use Commercializers (Real-World Examples): Company N, with a market cap of $2,300M+, got started with its hardened electronics for military environments and civilian applications. Company O markets holographic products to the commercial market that started with rugate filters for sensor protection of military optics.

DoD Key Technology Areas:

#1 --- Air Platforms
#5 --- Materials/Processes
#7 --- Sensors
#10--- Space Platforms
#12--- Weapons
#13--- Nuclear Technology

BMDO 02-009 Lethality and Vulnerability

Introduction: In implementing its TMD and NMD program activities, BMDO is continuing its developments of such efforts as the PATRIOT Advanced Capability-3 (PAC-3) missile system which has four major systems components: radar, engagement control station, launching station, and interceptors. The Navy Area Wide system will develop a sea-based capability that builds

upon the existing AEGIS/Standard Missile air defense system. This system is based on the AEGIS-class cruisers and destroyers, which provide all elements of missile defense and are particularly suited to protecting forces moving inland from the sea. The Theater High-Altitude Area Defense System (THAAD) system will form the largest umbrella of missile protection in a specific theater, arching over all other missile defense systems. THAAD consists of four major systems components: truck-mounted launchers; interceptors; radar system; and battle management, command, control, communications, and intelligence (BMC3I). These increasingly sophisticated systems will provide the opportunity to destroy short and medium range ballistic missiles and other threats in the atmosphere far enough away that falling debris will not endanger friendly forces. The various BMDO technology and acquisition programs, in support of the TMD and NMD missions, are continually evaluating the latest advanced technology developments from industry as potential replacements for the current state-of-the-art sensor systems, components, sub-components, or piece part specifics. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

Description: A major factor in determining the effectiveness of a ballistic missile defense is the lethality of the directed energy and/or kinetic energy devices used against responsively hardened targets, bulk powder, and submunition targets. Battlefield by-products of post-intercept events are currently under consideration. New concepts and technologies that produce a much higher probability of hit-to-kill intercepts are required to support applications. Ground and Point-of-Intercept technologies, instrumentation, diagnostic developments and concepts, and innovative methodologies are under consideration for cost effective incorporation into BMDO lethality efforts. Additionally, novel concepts and techniques that reduce the vulnerability of ballistic missile defense systems will increase the operational confidence level of dedicated assets. Commercial applications may benefit from the incorporation of the techniques utilized in cost-reduction, measurement and diagnostics, and meteorology instrumentation packages.

Phase I: Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

Phase II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

Successful Phase 3/Dual-Use Commercializers (Real-World Examples): Company P was started after receiving initial funding under this topic for its solid-state optical devices, which are now commercially available products.

DoD Key Technology Areas:

#1 --- Air Platforms
#5 --- Materials/Processes
#10--- Space Platforms
#12--- Weapons

BMDO 02-010 Computer Algorithms, and Models/Simulations

Introduction: BMDO investigates various computer technologies in support of both TMD and NMD applications. As such, a significant investment is made each year in the continued development of increasingly robust and sophisticated battle management, command, control, and communications (BMC3I) systems which may eventually find their utilization in, and support of a ballistic missile technology program or major defense acquisition program. All areas of computer software development provide potential avenues toward supporting the ability of future BMDO systems to find and disable a ballistic missile in flight. Furthermore, complete computer systems, components, sub-components, and piece part specifics are constantly under evaluation by the various TMD and NMD elements for replacement by the latest technology developments from industry. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

Description: Missile defense systems for advanced battle management demand order-of-magnitude advances. A system must potentially acquire and track thousands of objects with many networked sensors and data processors, and must employ direct weaponry to intercept targets, and determine the degree of kill. Areas of specific interest include:

- New computer architectures which are robust, compact, and fault-tolerant, but allow for the extremely rapid processing of data. Architectures may be implemented by new designs or innovative applications of existing technologies, such as optical signal processing, systolic arrays, neural networks, etc.
- Very high-level language (VHLL) design for both the development and testing of extremely large software systems.
- Novel numerical algorithms for enhancing the speed of advanced data processing for sensing, discrimination, kill assessment, and systems control. These may be specifically tailored to a particular task (for instance, the execution of a phase retrieval algorithm for interferometric imaging or advanced engagement planning) and may include neural networks.
- Language design to develop code optimized for highly parallel processed architectures.
- Software engineering processes, methods, tools, and environments for next generation revolutionary paradigms. Areas of interest include: decision architectures; COTS-based development; risk management; sizing and costing

estimation; measurement; affordability; supportability; quality; development and acquisition processes; and "Best Practices" for requirements specification/management, design, development, integration, testing, configuration management, and support of real-time distributed large-scale software systems.

- Software product line technologies, including domain analysis and engineering, software product line acquisition planning, component evaluation and cataloguing, organizational reuse assessments, and software product line risk management.
- Testing techniques that will provide a high level of confidence in the successful operation of concurrent, real-time, distributed large-scale software systems. Examples include sensitivity analysis, data flow testing, mutation testing, static concurrency analysis, dependency analysis, and novel techniques for early detection of errors.
- Computer network and communications security. Areas of interest include: intrusion-tolerant architectures; intrusion monitoring, detection, and defense; rapid recovery methodologies; "self-healing" systems capable of isolating corrupted nodes, re-allocating resources, and reconstituting lost information; R&D for trusted computer systems.
- Self-adaptive processing, simulations, and unconventional computing approaches. Algorithms and architectures for advanced decision-making. Data compression and adaptive bandwidth management techniques.
- Neurocomputing and Man-Machine Interface - rule-based artificial intelligence and neural networks combined for decision making flexibility and system robustness; development of decision trees and information display for highly, automated, short response time, training adaptive high volume scenarios development of autonomous intelligent agents and self-learning decision aids which operate in distributed heterogeneous environments.
- Software architectures for embedded computer networks that especially facilitate incremental system and software integration, hardware and software maintenance, and system evolution, without significant performance degradation.
- Hardware and software self-diagnostic capabilities for monitoring the operational readiness and performance of space, air, and ground systems incorporating embedded computer networks. Novel testing tools and evaluation methods supporting T&E capabilities.
- Virtual environments to allow diverse groups to interact in real time and in increasingly realistic ways over large distances which may include: hostile environments definition and ground effects modeling and simulation efforts. Real-time distributed database management.
- Advanced interface effectors, including visualization, multi-sensory, and virtual reality technologies, for total information presentation and improved situational awareness in missile defense application areas.
- Advanced knowledge representations and probabilistic behavior models for realistic, high performance knowledge-based decision aids.
- Software probes, gauges, and related software architectures and algorithms that support software/system re-composition to enable self-adaptive, self-healing computer-based systems.
- Application independent, customizable/adaptable middleware for real-time coordination and synthesis in networked embedded systems. Coordination services include fault tolerant, self-stabilizing protocols for time, data exchange, synchronization, and replication in large, distributed, real-time systems. Synthesis services provide time-bounded solution for complex, distributed constraint satisfaction tasks required for dynamic reconfiguration of applications.
- Model-based generation & composition technology: Includes methods and tools for modeling, composing, verifying and synthesizing model-based generators with domain-specific front-ends and platform/framework-specific back-ends; methods and tools for coupling and composing customizable frameworks.

Phase I: Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

Phase II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

Successful Phase 3/Dual-Use Commercializers (Real-World Examples): Company Q, with commercial and military sales of its automatic parallelization tool for sequential programs, marketed as *INSURE++* and *CodeWizard for Java*, is in excess of $10M/year.

DoD Key Technology Areas:

#1 --- Air Platforms
#3 --- Information Systems Technology
#10--- Space Platforms
#11--- Human Systems
#12--- Weapons

BMDO 02-011 Photonics

\Introduction: In implementing its TMD and NMD program activities, BMDO is continuing its developments of such efforts as the PATRIOT Advanced Capability-3 (PAC-3) missile system which has four major systems components: radar, engagement control station, launching station, and interceptors. The Navy Area Wide system will develop a sea-based capability that builds upon the existing AEGIS/Standard Missile air defense system. This system is based on the AEGIS-class cruisers and destroyers, which provide all elements of missile defense and are particularly suited to protecting forces moving inland from the sea. The

Theater High-Altitude Area Defense System (THAAD) system will form the largest umbrella of missile protection in a specific theater, arching over all other missile defense systems. THAAD consists of four major systems components: truck-mounted launchers; interceptors; radar system; and battle management, command, control, communications, and intelligence (BMC3I). These increasingly sophisticated systems will provide the opportunity to destroy short and medium range ballistic missiles and other threats in the atmosphere far enough away that falling debris will not endanger friendly forces. The various BMDO technology and acquisition programs, in support of the TMD and NMD missions, are continually evaluating the latest advanced technology developments from industry as potential replacements for the current state-of-the-art sensor systems, components, sub-components, or piece part specifics. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

Description: Dense computing capability is sought in all architectural variations, from all optic to hybrid computers. Specific examples of areas to be addressed include, but are not limited to, high speed multiplexing; monolithic optoelectronic transmitters; holographic methods; reconfigurable interconnects; in-plane optical connections; optoelectronic circuits; and any other technology contributing to advances in intra-computer communications; optical logic gates; bistable memories; optical clock oscillators; optical transistors; low-insertion,low-guide, and minimized bend losses; and power limiters. Also, under consideration are non-linear optical materials advancements and new bistable optical device configurations. Solutions that enable easy bi-directional opto-electronic conversion from vertical to in-plane interconnect schemes offer the ultimate in performance, I/O density and flexibility of design for system coupling. Please indicate the particular identifying letter that your specific proposal/technology addresses:

BMDO/ 02-211**A** – Optical Materials
BMDO/ 02-211**B** – Optical Devices

Phase I: Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

Phase II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

Successful Phase 3/Dual-Use Commercializers (Real-World Examples): Company R took a unique technology approach in addressing fiber-optic and other optical communications applications to both the military and commercial industry. Company S is providing a low-loss electro-optical switching array, Company T is providing optical bus extenders and fiber-optic modulators, Company U has funded technology which utilized wavelength division multiplexing techniques; all three support the ever growing optical communication industry.

DoD Key Technology Areas:

#1 --- Air Platforms
#3 --- Information Systems Technology
#5 --- Materials/Processes
#10--- Space Platforms
#12--- Weapons

BMDO 02-012 Structural Materials, Concepts, Components and Composites

Introduction: The tremendous explosion in the commercial industry to develop innovative structural components has sustained BMDO investigations into various technologies in support of both TMD and NMD applications. As such, a significant investment is made each year in the continued development of increasingly robust and viable concepts which may produce technologies that eventually find their utilization in, and support of, a ballistic missile technology program or major defense acquisition program. The commercial industry has made advances in the development of stronger, lighter, and cheaper materials for use in structural applications. BMDO investigates various composites technologies for both TMD and NMD missile applications. All considered technologies provide potential avenues toward supporting the ability of future BMDO systems to address vibrations and structural integrity more efficiently than current methods will allow. Furthermore, components, sub-components, and piece part specifics are constantly under evaluation by the various TMD and NMD elements for replacement by the latest technology developments from industry. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

Description: Minimum weight structures are needed in ballistic missile defense applications to withstand high-g loading, acoustic and thermal environments of ground based interceptors, and to provide solid bases for space systems pointing and tracking. Such structures will benefit from: (1) innovative vibration control techniques, (2) innovative fabrication approaches to cut structure cost, (3) innovative use of advanced materials and/or design approaches to minimize structure weight, and (4) innovative rapid prototyping techniques. For instance, techniques and experimental verification are needed for active and/or passive methods to measure and control vibrations caused by thermo-mechanical flutter, thruster firing, or structure borne noise caused by on-board mechanisms, multipurpose structures that provide mechanical strength, electrical connection, and desired

thermal characteristics, kill enhancement materials that increase the energy imparted to objects impacted. "Active" structural elements containing materials and electronics to provide predictable mechanical displacement in response to applied electrical signals are of interest. Maximization of displacement, mechanical strength, and reliability; parameter stability over extended temperature ranges; and minimization of driving voltage, power, and weight of these elements are desired. Producibility improvements for curved actuator elements, flextensional, and other integrated motion amplifiers are of interest. Fabrication approaches that provide minimum weight with reduced assembly, inspection, and scrap rates for conventional, advanced composite, and "active" structures are needed to reduce costs. The following are also sought: innovative manufacturing methods for producing high modulus, fiber-reinforced glass, light metal (i.e. aluminum or magnesium), or resin matrix composites; innovative procedures for the production of instrumentation, sensors, and software for on-line process monitoring and evaluation of high modulus, fiber-reinforced composites during fabrication; novel approaches to tailor fiber/matrix interfaces to maximize capability in advanced composites; novel methods to cut fabrication cost of metallic and/or composite spacecraft and interceptor structures; innovative tooling techniques for near-net shape production of advanced composites; novel low-to-no outgassing joining/bonding techniques for advanced composites; adhesives; innovative surface modifications to promote wear resistance and supersonic test techniques to evaluate wear and erosion; new methods for integrating instrumentation (e.g., embedded sensors) into advanced composite materials and structures; novel instrumentation for determination and telemetry of material properties and data from space. Advances are also sought in materials for optical system components, mechanical moving assemblies, and protective coatings. Of course, novel designs and material usage to reduce structure weight, while maintaining or increasing capability, are always desirable goals.

Phase I: Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

Phase II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

Successful Phase 3/Dual-Use Commercializers (Real-World Examples): Company V took its ultrasonic motor technology to the commercial industry and their motor can now be found in assorted novelty and gift items. Company W, with a very accurate and precise gimbal for military laser communications, also has sales to the commercial optical communications industry.

DoD Key Technology Areas:

#1 --- Air Platforms
#5 --- Materials/Processes
#10--- Space Platforms
#12--- Weapons

BMDO 02-014 Electronics and Superconductivity

Introduction: In implementing its TMD and NMD program activities, BMDO is continuing its developments of such efforts as the PATRIOT Advanced Capability-3 (PAC-3) missile system which has four major systems components: radar, engagement control station, launching station, and interceptors. The Navy Area Wide system will develop a sea-based capability that builds upon the existing AEGIS/Standard Missile air defense system. This system is based on the AEGIS-class cruisers and destroyers, which provide all elements of missile defense and are particularly suited to protecting forces moving inland from the sea. The Theater High-Altitude Area Defense System (THAAD) system will form the largest umbrella of missile protection in a specific theater, arching over all other missile defense systems. THAAD consists of four major systems components: truck-mounted launchers; interceptors; radar system; and battle management, command, control, communications, and intelligence (BMC3I). BMDO's increasingly sophisticated systems will provide the opportunity to destroy short and medium range ballistic missiles and other threats in the atmosphere far enough away that falling debris will not endanger friendly forces. The various BMDO technology and acquisition programs, in support of the TMD and NMD missions, are continually evaluating the latest advanced technology developments from industry as potential replacements for the current state-of-the-art sensor systems, components, sub-components, or piece part specifics. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

Description: The necessary advances in electronics for the many ballistic missile defense applications will require advances in electronics materials. Primary emphasis lies in advancing the capability of integrated circuits (>GB/s), detectors, sensors, large-scale integration, radiation hardness, and all electronic components. Novel quantum-well/superlattice structures that allow the realization of unique elective properties through "band gap engineering" are sought, as are new organic and polymer materials with unique electronic characteristics. In addition, exploitation of the unusual electronic properties of gallium nitride is of considerable interest, as well as, dramatic improvements of growth processes. Specific interests include, high speed switching conditions at >10GHz and/or cryogenic temperatures. Also, for high power, <10 GHz, SiC should be pursued for both semi-insulating bulk and epitaxial growth. Among the many BMDO electronic needs and interest are advances in high frequency transistor structures, solid state lasers, optical detectors, thermochromic films, low dielectric constant packaging materials, mixed-signal electronics, tailored thermal conductivity, microstructural waveguides, multilayer capacitors, single-electron

transistors, clock-less logic ICs, metallization methods for repair of conducting paths in polyceramic systems, and sol-gel processing for packaging materials. Also, BMDO is interested in demonstrating both high temperature superconductor (HTS) and low temperature superconductor (LTS) devices to enable or improve strategic defenses. Emphasis in HTS technology focused toward components integrated with state-of-the-art cryoelectronics for communications systems at K- and S-bands and radar systems in the X-band power and inductive energy storage are of specific ballistic missile defense interest. The demonstration of HTS materials toward limited detection of radiation in the optical, IR, MWIR, and LWIR bands as well as for signal processing applications is also of interest. The emphasis in LTS technology is in the development and demonstration of high sensitivity detectors, digital electronics, and memory enabling on-focal plane array signal processing and operating at temperatures greater than 10K. Additionally, superconducting power technologies are of interest. Efforts should address packaging and interface issues and systems integration with cryocoolers and stored cryogens. Please indicate the particular identifying letter that your specific proposal/technology addresses:

BMDO/ 02-214**A** – Electronic Materials
BMDO/ 02-214**B** – Electronic Devices
BMDO/ 02-214**C** – Superconductivity Materials
BMDO/ 02-214**D** – Superconductivity Devices

Phase I: Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

Phase II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

Successful Phase 3/Dual-Use Commercializers (Real-World Examples): Company Y, with a market cap of $883M+, commercialized technology that allowed for the delivery of ultra-pure materials to semiconductor thin film reactors and has graduated from small business status. Company Z, with a market cap of $14M+, manufactures radiation detection devices and was funded for avalanche photodiode arrays under this topic. Company AA, with a market cap of $1,200M+, has a substantial market share of the atomic layer epitaxy growth method of semiconductor compound materials based on their efforts developed under this topic. Company BB, with a market cap of $692M+, which manufactures flat panel display devices, received some initial funding for their silicon-on-insulator films and organometallic chemical vapor deposition technology developments. Company CC, purchased by a Fortune 100 company Apr 00, commercialized technology based on degradation resistant laser diodes. Company DD, with a market cap of $7M+, is commercializing technology based on its surge suppression devices and marketed as SurgX. Company EE, purchased by another larger company Feb 01 after graduating from small business status, had initial funding for its high bandgap compounds and laser diode products to develop a number of commercial and military products. Company KK established a multilayer coating technology, on which they have the worldwide patent, that can be easily transported to any location for application. Company FF developed a magnetoresistive non-volatile random access memory chip, which is also radiation hardened, and is utilized in a number of space applications for the military and commercial sectors. Company LL, with a market cap of $133M+, was started with their first Phase I from this topic and the products are used in electronics, structural ceramics, composites, cosmetics and skin care, and as industrial catalysts. Company NN, with a market cap of $574M+, is leveraging technology developed under this topic for the efficient production of semiconductors from waste recovery during the manufacturing process. Company GG, with a market cap of $113M+, fabricates optical components for industrial and military applications finds traceability back to superconducting detectors funded under this topic. Company HH, with a market cap of $103M+, demonstrated success from its technology based on multi-GHz superconducting shift registers.

DoD Key Technology Areas:

#1 --- Air Platforms
#5 --- Materials/Processes
#7 --- Sensors
#8 --- Electronics
#9 --- Battlespace Environment
#10--- Space Platforms
#12--- Weapons
#13--- Nuclear Technology

BMDO 02-016 Surprises and Opportunities

Introduction: BMDO increasingly depends on advanced technology developments, of all kinds, to invigorate its ability to find and disable missiles in flight and to defend against an increasingly sophisticated threat, to include cruise missiles. Therefore, the continued availability of emerging technology has become a vital part of the BMDO mission. BMDO has interest and investments in specific technology programs that pursue speculative, high-risk technologies that could spur a revolutionary leap or enhancements in either Theater Missile Defense or National Missile Defense capabilities. Specific goals include, but are not limited to, quickening the pace of technology and innovation developments and decreasing the time required to transform scientific breakthroughs into actual applications. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

Description: Since ballistic missile defense is an exploration at technology's leading edge to begin with, BMDO recognizes that surprises and opportunities may arise from creative and innovative minds in a variety of technology sectors. BMDO will consider proposals in other technologies where they present a completely unique and unusual opportunity for ballistic missile defense applications. The proposing company should take special care to describe the specific technology in complete detail and specify why ballistic missile defense applications would benefit from exploring its unique and novel implications. Proposing companies should make particular note that proposals in this topic will receive preliminary screening at BMDO and that they may be rejected as too far afield without the benefit of a full technical review received by proposals in the topics already listed. It is recommended that the proposing company focuses their submission toward one of the specific outlined topics above unless the technology proposed is truly an unquestionable innovation. This full and open call is for new/novel/innovative/unique advanced technology developments, and not for the recycling of old ideas, incremental advancements, or questionable improvements.

Phase I: Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

Phase II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

Successful Phase 3/Dual-Use Commercializers (Real-World Examples): Company JJ, with a market cap of $999M+, was funded for technology to further its intelligent client-server software solutions for mission-critical decision applications in real-time military and commercial environments.

DoD Key Technology Areas: Any potential new development may address a DoD Critical Technology Area from this topic, provided it supports BMDO mission interest at some level. DoD Key Technology Areas:

#1 --- Air Platforms
#3 --- Information Systems Technology
#4 --- Ground and Sea Vehicles
#5 --- Materials/Processes
#7 --- Sensors
#8 --- Electronics
#9 --- Battlespace Environment
#10--- Space Platforms
#11--- Human Systems
#12--- Weapons
#13--- Nuclear Technology

DEFENSE THREAT REDUCTION AGENCY

The Defense Threat Reduction Agency (DTRA) is actively involved in meeting current threats to the Nation and working toward reduction of threats of all kinds in the future. To meet these requirements, the Agency is seeking small businesses with strong research and development capability. Expertise in weapons effects (blast, shock and radiation), arms control, and counter-proliferation technologies will be beneficial. Proposals will be accepted only by electronic submission at www.dodsbir.net.

The proposals will be processed and distributed to the appropriate technical offices for evaluation. Questions concerning the administration of the SBIR program and proposal preparation should be directed to:

Defense Threat Reduction Agency
ATTN: Mr. Ron Yoho, Program Manager
DTRA/TDC
8725 John J. Kingman Drive, MSC 6201
Fort Belvoir, VA 22060-6201
E-mail: ron.yoho@dtra.mil

Use of e-mail is encouraged for correspondence purposes.

DTRA has identified 10 technical topics numbered DTRA 01-001 through DTRA 01-010. These are the only topics for which proposals will be accepted. The current topics and topic descriptions are included below. The DTRA technical offices, which manage the research and development in these areas initiated these topics. Several of the topics are intentionally broad to ensure any innovative idea fitting within DTRA's mission may be submitted. Proposals do not need to cover all aspects of these broad topics. Questions concerning the topics should be submitted to Mr. Yoho at the above address or to the topic POC identified with the topic.

Potential offerors must submit proposals in accordance with the DoD Solicitation document. Proposal selection will be limited to those, which do not exceed $100,000 and six months of performance. For information purposes, Phase II considerations are limited to proposals of $750,000 and 24 months of performance or less.

DTRA selects proposals for funding based on the technical merit of the proposal, criticality of the research and the evaluation criteria contained in this solicitation document. As funding is limited, DTRA reserves the right to select and fund only those proposals considered to be superior in overall technical quality and filling the most critical requirements. As a result, DTRA may fund more than one proposal under a specific topic or it may fund no proposals in a topic area. Proposals, which cover more than one DTRA topic, must be submitted once - referencing the several areas of applicability.

While funds have not specifically been set aside for bridge funding between Phase I and Phase II successful proposals, the potential offeror is advised to read carefully the conditions set out in this solicitation for FAST TRACK Phase II awards.

In order to enhance Phase II efforts and to assist in assuring acquisition support from the DTRA SBIR program, the Agency may provide a Phase II Awardee with additional Phase II SBIR funding beyond the initial award sum. The additional funding is conditioned on the company matching the additional SBIR funds with DoD acquisition funds or monies provided from external sources. At the discretion of the DTRA requiring activity, additional dollars may be provided by DTRA activities with heavy interest in the areas of endeavor being pursued by the Phase II award recipient under the SBIR contract applying the same matching arrangement. These conditions will be applicable to awards made pursuant to this DoD Solicitation and subsequent solicitations, for a trial period of three years. This is the third of the three-year period.

Notice of award will appear first in the Agency Web site at http://www.dtra.mil. Unsuccessful offerors may receive debriefing upon written request only. E-mail correspondence is considered to be written correspondence for this purpose and is encouraged.

DEFENSE THREAT REDUCTION AGENCY FY 2002.1 TOPIC DESCRIPTIONS

DTRA 02-001 TITLE: Agent Defeat Weapons based on High Temperature Incendiaries

TECHNOLOGY AREA: Chemical/Biological Defense, Materials/Processes, Weapons

BACKGROUND
DTRA is developing weapon concept(s) to defeat enemy biological and chemical facilities without causing significant collateral effects (that is, without releasing live agents into air). DTRA has developed a group of high temperature incendiaries (HTI) that are efficient in killing dry spores when properly mixed. HTIs are shown to react from heat or shock inputs. In nominal weapon-target interaction configurations, both types of HTI reactions were shown to create enough mixing between HTI reaction products and dry spores to kill most of the spores.

REQUIREMENT:
All these point to a promising technology. However, for a weapon to be successful, it needs to be effective against a variety of targets in various adverse conditions, without causing undue collateral effects. There are different types of target structures (above-ground, cut-and-cover, or deeply buried), different types of agents (dry spores, vegetative cells, viruses, toxins, chemical agents), different types of containment of agents (plastic, steel, large, small), etc. Then there are uncertainties of target configuration (doors, windows, stand-alone containers, stacked containers, dividing walls), and issues of accuracy of weapon functioning, etc.

DESIRED:
New and innovative technologies and approaches to address the above requirement are sought for. These might include new types of energetic materials that can create hostile environment (e.g. more caustic reaction products) to the agents effectively (e.g. effective mixing by tailored blasts or effective heat transfer by slower burning). These might include devising better ways of killing all agents mentioned above. Or, these might include designing effective weapon concepts against a variety of targets. These still might include creative approaches to efficiently validate the weapon concepts against a variety of the above-mentioned parameters.

PHASE I:
Identify and execute exploratory investigations for possibilities of development of a new and innovative agent defeat weapon concept or its component.

PHASE II:
Build and test prototype agent defeat weapons based on Phase I effort.

PHASE III:
A successful proof-of-concept test of an agent defeat weapon be conducted based on earlier efforts. Potential commercialization applications include environmental site remediation.

KEY WORDS: agent defeat, biological agents, chemical agents

DTRA 02-002 TITLE: Reliable Identification of Secondary Seismic Phase Arrivals

TECHNOLOGY AREA: Information Systems

OBJECTIVE: Innovative Techniques for Improved Determination of the Arrival of Secondary Seismic Phases in the Seismic Signature from Explosions.

DESCRIPTION: Since 1992 the U.S. has observed a moratorium on the testing of nuclear devices. However, monitoring for nuclear explosions by other states continues. One component of nuclear explosion monitoring system are networks of seismic sensors. A key parameter produced by processing the data from such networks is the location of a seismic event (including explosions), the hypocenter (latitude, longitude, depth). DTRA is pursuing a number of research topics to improve hypocenter estimates and reduce the parameter uncertainty. A reduction in uncertainties will reduce the geographic area to be examined, thereby increasing the probability that the site of a clandestine test could be located. Furthermore, better definition of the uncertainty ellipse would assist the U.S. in determining the appropriate response, especially where the possible location of the explosion was near political boundaries or land/sea interfaces. This topic addresses the use of secondary seismic phases in determining hypocenter estimates and associated uncertainties.

Secondary seismic phases (such as pP, Sn, and Lg) can enhance the solution of the hypocenter. However, an examination of selected "calibration" events maintained by the Center for Monitoring Research (CMR, DTRA contractor; see web site below) has shown that the selected arrival times and/or phase identification for the secondary phases are inconsistent. Different analysts have picked different arrival times. Therefore, using these arrival times to calculate the hypocenter may increase the uncertainty rather than enhance the accuracy of the location of the hypocenter.

The contractor should propose innovative criteria and an automated process for establishing arrival times of secondary seismic phases and articulate a corresponding theoretical basis.. DTRA is therefore interested in an automated process that will: (1) Reliably identify when such phases come into each station, (2) Assign a meaningful reliability estimate to the determined arrival time, and (3) Relate this reliability to the model reliability and the primary phase arrival time reliability estimate. The desired research may involve multi-component processing and array processing.

PHASE I: Develop overall system design and demonstrate proof-of –concept.

PHASE II: Produce prototype software modules and conduct tests showing validity of approach.

PHASE III DUAL USE APPLICATIONS: Better and more rapid location of explosions, thereby improving the probability of locating the source of the explosion. Also can provide better and more rapid location of earthquakes, thereby allowing better determination of responders, especially near political boundaries. Will also allow rapid determination of future seismic hazards.

REFERENCES: www.cmr.gov

Tibuleac, Ileana and Herrin, E. T., "An Automatic Method for Determination of Lg Arrival Times Using Wavelet Methods", Seismological Research Letters, 70, 577-595.

Zhao, L.-S. and C. Frohlich, "Determination of Near-Station Crustal Structure and the Regional Seismic Event Location Problem", Proc., 17th Annual Seismic Research Symposium, edited by J. F. Lewkowicz, J. M. McPhetres, and D. T. Reiter, 941-950, 1995.

Song, Xi and Helmberger, Donald V., "Pseudo Green's Functions and Waveform Tomography", Bull. Seismol. Soc. Amer., v. 88, No. 1, p. 304-312, 1998.

DTRA 02-003 TITLE: <u>New Sensors to Discriminate Between Nuclear Explosions and Chemical Explosions or Natural Events</u>

TECHNOLOGY AREA: Sensors

OBJECTIVE: Develop innovative sensors whose outputs may be combined with seismic signals to distinguish between nuclear explosions, chemical explosions, or natural events.

DESCRIPTION: Global networks of sensors have been, and are being, deployed to monitor for clandestine nuclear tests. One processing center for data from such a network is being developed at the Center for Monitoring Research (CMR) in Arlington VA. The sensor data streams at CMR include seismic, hydroacoustic, infrasound and radionuclide sensors. A potentially powerful means of identifying the type of source of events ("discrimination"), particularly small events, in the seismic stream is to combine the seismic signals with signals from one or more of the other sensor data streams ("data fusion"). Identification of these small events, however, can still be problematic, with difficulties in distinguishing between small nuclear explosions, chemical explosions, and small earthquakes. Therefore, DTRA has a need for the development of sensors other than the ones currently being used (hydroacoustic, infrasound, and radionuclide) to assist in the identification of source type for small events in the seismic data stream. Innovative approaches, such as sensors detecting changes in the Earth's gravity field or magnetotelluric fields, may be of interest. (This SBIR topic, however, is not restricted to these two approaches – other approaches may also be of interest.) These sensors should be capable of detecting these changes at distances of several thousand kilometers. Space-based sensors, however, will not be considered. The work should include appropriate algorithms to carry out the identification of source type.

PHASE I: Carry out preliminary design of proof-of-concept tests.

PHASE II: Build prototype/acquire sensor(s), conduct tests sufficient to demonstrate proof-of-concept.

PHASE III DUAL USE APPLICATIONS: A successful proof-of-concept test could lead to deployment of a new sensor network to assist in nuclear explosion monitoring. Additionally, sensors based on measurements of the earth's gravity field or electromagnetic field could lead to improved scientific monitoring of the earth. These types of sensors, or sensors based on other principles, could be used to detect and monitor natural events (included those potentially hazardous).

REFERENCES: www.cmr.gov
"A Fifty Year Commemorative History of Long Range Detection, The Creation, Development, and Operation of the United States Atomic Energy Detection System", HQ Air Force Technical Applications Center, Patrick Air Force Base, Florida, September 1997.

KEYWORD LIST: seismic signals, nuclear explosions, chemical explosions, discrimination, fusion, sensors, gravity field, magnetotelluric fields

DTRA 02-004 TITLE: <u>Botanicals as Chemical Warfare Agent Indicators</u>

TECHNOLOGY AREA: Chemical/Biological Defense

OBJECTIVE: Develop a sensing system designed to detect differences between ordinary plants, and those exposed to Chemical Warfare (CW)-related compounds (and their degradation products) in an ambient environment.

DESCRIPTION: The US DoD has a need to protect its personnel, as well as civilians under the protection of US troops, from recently deployed chemical weapons. These materials can be particularly threatening to troops on battlegrounds and terrorist attack zones. No rapid screening or detection methods exist to assure that these areas are free from such hazards. Detection technologies such as these could also greatly benefit

US contributions to the Convention on the Prohibition of the Development, Production, Stockpiling, and Use of Chemical Weapons and on Their Destruction (CWC) under alleged use scenarios.

The Defense Threat Reduction Agency (DTRA) is responsible for providing RDT&E support to protect DoD assets and equities from CW threats. DTRA, therefore, is seeking innovative techniques to detect specific and definitive plant "stress" occurring from exposure to CW-related compounds. DTRA has found that most CW agent detectors are designed to directly detect the agents themselves, rather than employ environmental indicators such as vegetation to identify chemical weapons storage, manufacture, or use. Botanicals' behavior in these circumstances may prove to be an excellent indicator to determine CW-related compound contaminated areas.

This solicitation seeks R&D concerning the CW-related compound effects on botanicals. Proposals may range over a wide purview of subject matter that include:
(1) theoretical analysis coupled with experimental testing of plant effects caused by exposure to toxic chemicals that may be introduced into the environment;
(2) development and/or testing of instruments that can exploit the plant indicators to produce measurable signals and,
(3) signal processing technology to improve the level of detection of the toxified plant with high background signal clutter.

It is well known that some plants exhibit symptoms of stress upon exposure to organophosphorous pesticides that chemically resemble some nerve agents. However, little research has been done to determine botanical reactions to any of the agents themselves. The mechanism(s) by which CW molecules affect plants appears poorly understood. Perceptible and exploitable effects may include variations in: (1) spectroscopic patterns from leaves; (2) plant structural growth or behavior; (3) variation in volatile plant chemicals produced; (4) soil chemistry; and (5) plant species, in addition to other variables or properties not elaborated.

Chemical agent possession is tightly controlled in the US. Access to these materials is neither required, nor desirable for proposals to this solicitation, as most plants would only be exposed to dilute solutions of CW primary degradation compounds. (e.g., phosphonic acids from nerve agents or thiodiglycol for mustard).

PHASE I: Demonstrate proof of concept of using vegetation as indicators of CW-related molecule exposure in the environment. Document the testing procedures, the measured environmental influences on the plants, statistically-significant testing, raw test data, test statistical results and provide premises, caveats, test result interpretations, findings and recommendations in a Final Report.

PHASE II: Develop concept demonstrated in Phase I that exploits measurable plant effect(s) to detect chemical agents using vegetation for on-site screening. Develop an analytical procedure/ instrument prototype and determine its utility in sensing CW-related molecules. Conduct tests to obtain performance features and limitations. Field testing may be performed at a facility to be determined by DTRA. Submit final prototype design, testing procedures, test results, findings and recommendations in a Final Report.

PHASE III: Develop the product of Phase II to provide a practical technology that will be attractive for military or homeland defense applications. Conduct testing and evaluation to extend its utility to detect pesticides and other environmental residues or contamination, narcotic processing chemicals and unusual flora. Commercialization potential includes environmental protection applications for monitoring exposure to pesticides, herbicides, etc.

REFERENCES:

1. Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction, 13 January 1993. (http://www.opcw.nl/cwc/cwc-eng.htm)

KEYWORD LIST: Sensor, Chemical Weapons, CWC, Fluorescence, Indicators, On-Site Analysis.

DTRA 02-005 TITLE: Sub-Lethal Chemical Weapons Exposure Detection in Humans

TECHNOLOGY AREA: Chemical/Biological Defense, Biomedical

TECHNOLOGY AREAS: TWO PRIMARY AREAS: 1)Chemical/Biological Defense, and 2) Biomedical

OBJECTIVE: To develop non-serum based chemical detection systems to test for human exposure to chemical agents. Results from this project will benefit forensic studies for chemical & biological defense, homeland defense, law enforcement, environmental testing, and will also promote the advancement of non-invasive testing in the medical diagnostic community.

DESCRIPTION: When warfighters return from an unknown enemy area where chemical weapons were potentially used, manufactured, or stored, it is difficult to confirm if soldiers were exposed to sublethal levels of chemical weapons. Current solutions center around advance site monitoring before soldiers enter, but these technologies may not be able to adequately detect sub-lethal CW levels in the air, water, or on surfaces. Furthermore, current technologies track potential exposure rates on a per-incident basis, and do not track cumulative exposures of each soldier over time. For these measurements, the military relies upon blood and urine screening of each individual soldier. These samples must be collected sometimes under field conditions and samples must be taken frequently. However, the samples only represent a "snapshot" measurement. In a battlefield environment, the logistics of this monitoring effort are burdensome, impractical to execute, and may lead to incorrect results if samples are not stored and analyzed within specified holding times. Low-level CW detection in humans is even more difficult when non-DoD personnel must be tested (such as in a terrorist or military attacks), as blood sampling is invasive and the most common procedures for on-site testing require baseline blood tests that cannot be obtained post-attack. Therefore, a need exists for less invasive, low-level CW exposure testing that requires no individual background sampling of blood or urine.

The Defense Threat Reduction Agency (DTRA) provides R&D support to protect DoD assets and equities from WMD threats. DTRA, therefore, is seeking innovative technologies to detect low-level CW exposure in humans. Preferred techniques should not require blood sampling or testing which requires background study on each patient. DTRA has reviewed other CW R&D efforts sponsored by the US Government (USG), and has determined that other CW detection efforts in humans focus either on acute exposure, are too invasive to be practical in a battlefield situation, or are too labor intensive to conduct on a quick-turnaround or high throughput basis.

This solicitation seeks R&D efforts to detect CW agents, their degradation and precursor compounds, and simulant chemicals that model the behavior of the various CW compounds (hereafter called target compounds). Due to restrictions on the use and handling of CW compounds, research should focus on non-agent compounds exclusively for this Phase I request for proposal. Animal testing in vivo is not required to qualify for Phase I awards, however the research test matrix must resemble a human matrix. Acceptable sampling matrices include hair, nails, skin, skin scrapings, or glandular excretions, but may not include blood, urine, internal tissue organs, or any other sample matrix that is invasively sampled. Proposals may address a variety of topics that include:

(1) theoretical analysis coupled with experimental testing of long-term CW-related compound exposed samples;
(2) research and development of instruments or methods that can detect CW-related compounds obtained non-invasively from human matrices;
(3) detection of target compounds where they are absorbed by the body after an attack, or excreted by the body such as hair, nails, skin, etc . (other than urine and feces);
(4) extraction techniques to facilitate on-site and rapid detection of the desired matrix.

Techniques that employ on-site testing or sample extraction techniques are highly desirable. Detection techniques may, but are not required to detect the target compounds themselves. Proposals may also address the detection of changes in human physiology that result from CW exposure.

PHASE I: Demonstrate proof of concept using sample matrices to detect sub-lethal levels of target compounds; document the sampling requirements and testing protocols, results, and conclusions resulting from the study, and provide recommendations for continuing research.

PHASE II: Develop concept demonstrated in Phase I for actual on-site application; develop testing procedure to detect chemical agent; demonstrate prototype's utility in sensing CW in non-invasively obtained human matrices; refine sampling and analysis methodology; conduct prototype development; provide analytical data.

PHASE III: Reduce the technique developed under Phase II to high volume assays; improve prototype instrument design to reduce cost and provide a system that will be attractive to use in multiple areas of military or homeland defense projects; perform extensive testing of the prototype to develop a marketable product. Commercialization potential includes pharmaceutical industry and environmental protection applications for monitoring exposure to pesticides, herbicides, etc.

REFERENCES:
1. Convention on the Prohibition of the Development, Production, Stockpiling, and Use of Chemical Weapons and on their Destruction, 13 January 1993.

KEYWORD LIST: Sensor, Chemical Weapons, detection, on-site, sampling, analysis, method development, hair, skin, CWC

DTRA 02-006 TITLE: Particulate Mass Flow

TECHNOLOGY AREA: Materials/Processes , Sensors, Electronics, Battlespace

OBJECTIVE: Develop an instrument that can measure mass flow rates in the products produced by the detonation and or deflagration of an energetic material.

DESCRIPTION: DTRA is currently testing the effects of energetic materials on structures or the contents of structures. Amongst the effects are the loads produced by the fireball that result from the detonation or deflagration. This fireball can contain particulate matter that varies in composition. The object of this effect will be to do the research necessary to produce/innovate a gage or measurement technique that can determine the mass flow rate of this particulate matter in the gases within the fireball. The gage will have to work in thermal environments that can range up to 3000 C. The mass density of the particle can vary widely. It could be, as examples, metal oxides or free carbon. The object is to measure the rate at which particulate mass passes through a given area or the particulate mass flux. The respondent in his proposal should estimate the accuracy and achievable frequency response of the measurement. The frequency response may vary as a function of the particulate size and mass flux.

During Phase I, build a prototype of the gage or system of transducers and demonstrate with laboratory tests and/or small scale field tests that one can infer the particulate mass flux.

During Phase II, build and field a number of the instruments on tests to be specified by DTRA.

PHASE III COMMERCIALIZATION: In addition to the Department Of Defense (DOD) applications, the technology developed will be useful in cloud analysis, smoke stack emissions, and internal combustion engine emissions.

KEYWORD LIST: Stress, Normal Stress, Hard Rock, Conventional Weapons Effects, Nuclear Weapons Effects, Stress Wave Propagation.

DTRA 02-007 TITLE: The Measurement of Stress in Hard Rock

TECHNOLOGY AREA: Materials/Processes, Sensors, Electronics, Battlespace

OBJECTIVE: Develop an instrument that can reliably measure normal stress in hard rock and help study stress wave propagation in Rock.

DESCRIPTION: DTRA conducts conventional weapons effects tests and simulated nuclear weapons effects tests using high explosives. Often these tests are conducted in hard rock (such as granite) test beds. The measurements done are usually those from which particle velocity can be inferred. It would also be advantageous to measure normal stress. It should be noted that these test beds can be large. The gages may be place in boreholes that can be of the order of 100 meters long. The basic requirement is to obtain data that can be used to infer the normal stress-time history of the stress wave in the rock. The respondent should be able to demonstrate in the laboratory that the proposed technique is a measurement of normal stress. The technique does not necessarily have to be a direct measure of the normal stress time history, it is only required that the normal stress-time history can be inferred from the measurement. Ease of placement of the gage in boreholes will be one of the criteria used to judge the candidate proposals.

During Phase I, build prototypes of the gage and demonstrate with laboratory tests and/or small scale field tests that one can infer both peak stress and stress-time history using the instrument.

During Phase II, build and field a number of the instruments on tests to be specified by DTRA.

PHASE III COMMERCIALIZATION: In addition to the Department Of Defense (DOD) applications, the technology developed will be useful in mine safety applications, shale oil extraction and earthquake prediction and analysis.

KEYWORD LIST: Stress, Normal Stress, Hard Rock, Conventional Weapons Effects, Nuclear Weapons Effects, Stress Wave Propagation.

DTRA 02-008 TITLE: Fuel Cells for Arms Control Applications

TECHNOLOGY AREA: Materials/Processes, Sensors

OBJECTIVE: DTRA requires a man-portable fuel cell capable of producing 220 watts of continuous direct current (DC) electrical power for a nominal 12 hours without refueling. The weight of the fuel cell must be such that a person of average strength could carry the unit for a short distance. The fuel cell must be easily refuelable in the field by non technical personnel (e.g., through "clip-in/drop-in" ampoules of fuel) in a way that would not pose a hazardous material risk prior to use, during use in the fuel cell, or following use. The fuel cell, less fuel, must be rugged and transportable as checked baggage on commercial airlines. Furthermore, it must be effective in a wide range of temperatures and other variable environmental conditions.

DESCRIPTION: Technologies capable of verifying future arms control agreements will require self-contained and man-portable power modules for operation in remote locations. Whether the fundamental activity is a part of a portable instrument or an unattended system, long-term power provision in a lightweight, self-contained package is necessary. Power modules may be used to intermittently power computer equipment, video monitoring equipment, or environmental sensors, but the highest power consumption is undoubtedly from thermal cycling applications. Many measurement systems have been demonstrated whose performances are power-limited in remote or rugged applications. Standard power sources are either inordinately heavy/immobile (generators), contribute to operational hazards, or store insufficient energy for the desired applications (e.g., batteries). During on-site inspection activities, the logistics of providing power rapidly becomes the limiting operational factor.

A lightweight high-performance long lasting power module is advantageous because it lowers the support burden, either reducing the number of resupply trips necessary or the amount of equipment needed to transport to an inspection. Currently available fuel cells are bulky, inefficient, and unable to produce the sustained energy required. In both storage and operation, a longer working lifetime is desirable.

The developed fuel cell should employ an innovative approach combining size and power storage capacity with output control modules to maximize the utility and application of the fuel cell. A preference will be given to adaptive learning or control algorithms over hard-wired selective outputs.

PHASE I: Develop a system design based on providing 220 watts of continuous DC electrical power for 12 hours. Demonstrate that the weight of the power module will be such that a person of average strength could carry the unit for a short distance.

PHASE II: Develop and demonstrate a prototype system with a weight, ruggedness, and environmental resistance sufficient to field the fuel cell under harsh conditions. The fuel cell must be easily refuelable in the field by non technical personnel (e.g., through "clip-in/drop-in" ampoules of fuel) in a way that would not pose a hazardous material risk prior to use, during use in the fuel cell, or following use. The fuel cell, less fuel, must be rugged and transportable as checked baggage on commercial airlines. Furthermore, it must be effective in a wide range of temperatures and other variable environmental conditions. Conduct testing to prove feasibility over extended operating conditions.

PHASE III: DUAL USE APPLICATIONS: A portable fuel cell has a wide variety of military and commercial applications in surveillance and security. Examples are remote and perimeter monitoring, securing industrial facilities, and providing power at emergency locations.

KEYWORD LIST: Arms control verification, arms control compliance, fuel cells and batteries, portable power sources, unattended monitoring.

DTRA 02-009 TITLE: <u>Nuclear Weapon Surety Risk Management</u>

TECHNOLOGY AREA: Materials/Processes, Weapons, Nuclear Technology

OBJECTIVE: Improved Surety of US Nuclear Weapons Systems

DESCRIPTION: Quantifying, reducing, and managing the risks associated with the life-cycle management of military weapon systems, including demilitarization activities, is of vital importance to ensure the safety, security, and control of our nation's nuclear weapons stockpile. To this end, several nuclear weapon system safety assessments and special studies have been or are currently being conducted by the Defense Threat Reduction Agency (DTRA). These use probabilistic risk assessment techniques primarily to quantitatively estimate the likelihood of plutonium release from weapons associated with various delivery platforms resulting from accident-induced abnormal environments. Abnormal environments may include mechanical insults (e.g. drops, vehicle accidents), thermal insults (e.g. fuel fires), electrical insults (e.g. lightning), and combinations of these environments. These risks are estimated to be quite small, but the assessments allow component commanders to better balance the prevention and mitigation of accidents against the potential cost of consequence management and operational requirements by focusing limited resources in those areas which have the greatest potential to continue improving overall stockpile surety. Long-range program thrusts include characterizing these abnormal environments, through test and modeling/simulation, analyzing human factors that can be a significant source of hazards, and developing and integrating quick running codes/models to allow decision makers to manage surety risks. Innovative concepts to improve and extend these techniques and methodologies are desired to continue improving the safety, security and control of the Nation's nuclear weapons stockpile, as well as applying these techniques to other areas of interest to the Department of Defense. DTRA is particularly interested in the following areas of study, which can be evaluated individually of grouped together: 1) analysis and prevention of environments leading to inadvertent nuclear detonation (IND), 2) prediction of consequences from plutonium dispersal and IND in terms of litigation and site restoration, 3) determine a combinatorial optimization of logistics

movements to reduce plutonium dispersal risk, and 4) determine the global probability of a terrorist attack on a facility on any given day that can be combined with other probabilities for success or failure given the attack.

PHASE I: Demonstrate the feasibility and potential usefulness of the proposed technology or technique.

PHASE II: Fully develop the proposed technology or technique so they can be compared to existing techniques.

PHASE III DUAL USE APPLICATIONS: Hazard/risk analysis tools and techniques have wide applicability. They are currently used in a variety of high-risk/high-consequence activities, such as space shuttle operations, chemical plant operations, nuclear power operations, ocean engineering, and hazardous waste cleanup. As risk analysis tools and techniques become more prevalent, these techniques may be more quickly and efficiently applied to a greater variety of applications where safety and security risks must be managed. Military organizations may apply these tools through detailed assessments in concert with operational risk management principles; these support operational decisions as well as planning functions. Other federal, state, and local governments may require the use of these tools as the threats of terrorism on U.S. soil increases and the potential for nuclear-related industries who have lost experienced personnel see the demand increase in the near future.

KEYWORDS: Surety, Safety, Security, Use Control, Risk, Nuclear Weapons, Abnormal Environments, Mechanical Hazard, Thermal Hazard, Electrical Hazard, Human Factors, Risk Reduction, Accident Initiators, Probabilistic Risk Analysis, Risk Mitigation, Risk Management, Consequence Management, Accident Prevention, Optimization, Terrorist.

DTRA 02-010 TITLE: X-Ray Simulators and Other Pulsed Power Applications

TECHNOLOGY AREA: Sensors, Electronics

OBJECTIVE: Develop innovative technologies for the efficient production of x-rays for nuclear weapons effects testing and for the application of compact pulsed power to military and civilian systems.

DESCRIPTION: X-ray nuclear weapon effects testing uses radiation sources that generate primarily cold x-rays (1-15 keV), warm x-rays (5-60 keV), or hot x-rays (>30 keV). Soft x-rays are used for optical and optical coatings effects testing; warm x-rays are used for thermomechanical and thermostructural response testing; and hot x-rays are used for electronics effects testing. Future requirements for x-ray nuclear weapon effects testing will require substantial improvements in existing radiation source capability, to increase yield and power by 1-3 orders of magnitude, improve spectral fidelity, and increase predictability and experimental control. These improvements may require new concepts in source design, power generation, pulse compression, experimental and measurement techniques, data analysis and modeling, and methods to reduce facility system and operation costs. The proposer should be familiar with the present capability to produce x-rays for nuclear effects testing.

Plasma Radiation Source (PRS) devices are typically gas puffs or wire arrays that are imploded by conduction of large currents to generate soft x-rays. Present PRS designs for high-power DTRA simulators are limited by Rayleigh-Taylor and MHD instability growth, thus innovative load designs may allow for more efficient production of x-rays to meet the goals of increasing fluences by 100-200%. An important contribution could come from physics-based modeling of this complex system, particularly with the high-performance parallel computers now available.

PRS devices generate copious amounts of extraneous debris (material, atomic charged particles, sub-keV photons), from which test objects must be shielded. Debris shields must minimize particle flux and maximize exposure area without significantly reducing x-ray fluence. New, innovative methods, or a combination of methods, may be needed to stop, mitigate, and/or delay debris generated for radiation simulators.

The latest generation of DTRA high-power generators has a relatively large pulse length (~300 ns) which is problematic for both plasma radiation sources and brehmsstrahlung sources. Novel pulse compression technology, including plasma opening switches (POS), flux compression, and even current multiplication could be important for obtaining maximum performance from these x-ray sources. Better computer modeling is needed, especially to understand the opening process in POS and its relationship to conduction dynamics, as well as the dynamics of flux compression.

Bremsstrahlung Radiation Source (BRS) devices generate hot x-rays by impinging an electron beam onto a target converter. Innovative BRS converter and/or beam transport designs are needed to meet future test requirements, by increasing x-ray production (dose) by as much as 3 orders of magnitude, better tailoring pulse width (increased dose rate by as much as 1 order of magnitude), and improving spectral fidelity. These improvements could be effected by innovative new BRS designs, or by better understanding and refinement of existing BRS designs. Comprehensive computer modeling (e.g., PIC codes) of cathode formation and electron emission, beam transport, and/or converter physics, could provide an important contribution.

Diagnostics are critical for understanding how radiation simulators (cold, warm, or hot) are operating and how their performance can be improved. For example, in a PRS machine, these diagnostics are needed during all of the phases of implosion: current build-up, run-in, pinch, and bounce. Innovative diagnostics that can determine with good accuracy the electron density, neutral density, electron temperature, ion temperature, neutral temperature, radiation spectrum, and magnetic field structure, both spatially and temporally resolved, would be a boon to the overall radiation simulator program. In addition, absolutely calibrated x-ray power measurements in different energy spectrums are necessary. Innovative diagnostics are needed to accurately determine the fluence and spectrum of x-rays produced in both cold and hot x-ray simulations.

Future requirements for systems employing pulsed power will necessitate improvements in efficiency, energy density, reliability, repeatability and overall performance over the existing state of the art. Innovative approaches for component or subsystem development are sought to meet future demands for radiation simulators and other pulsed power applications. Examples include more energy efficient pulse forming technologies, high energy density capacitors, more efficient insulators, improved and more reliable switching technologies, and improved power flow electrical circuit models. Pulsed power technologies include those that operate at kilovolts to megavolts and kiloamperes to megamperes, support repetition rates from single pulse to 10 kilohertz, and provide individual pulse risetimes in the nanosecond to millisecond range.

Current DoD pulsed power applications includes x-ray simulators, armor/anti-armor; electromagnetic/electrothermal guns; mine-countermine; electrical vehicle stoppers, and directed energy weapons; etc. Development of new and innovative applications requiring advanced pulsed power technology is also desired, especially applications that may expand a primarily DoD driven requirements base into the commercial sector and reduce component and system costs.

PHASE I: Demonstrate the feasibility of the proposed concept.

PHASE II: Develop, test and evaluate proof-of-principle hardware. In the event the contractor proposes to demonstrate the prototype in an above ground test simulator, DTRA will coordinate the demonstration at its facility.

PHASE III DUAL USE APPLICATIONS: In addition to the applications cited for developing the environments for simulating the effects of nuclear weapons, the technologies could be useful with the commercial operations of advanced computer modeling of plasmas, nuclear instrumentation, very fast closing valves, material surface treatments, environmental clean-up and high brightness x-ray sources. In addition to the DoD applications cited, these pulse power component technologies will be useful in cleaning up smokestack effluents, general environmental pollution control, metal cutting, and electric vehicles.

REFERENCES:

(1) Inductive Energy Technology for Pulsed Intense X-Ray Sources, K. D. Ware, P. G. Filios, R. L. Gullickson, J. E. Rowley. R. F. Schneider, W. J. Summa, I. M. Vitkovitsky, IEEE Transactions on Plasma Science, Vol. 25, No. 2, April 1997.

(2) Glasstone and Dolan, The Effects of Nuclear Weapons, 1977

(3) DNA EM-1, Capabilities of Nuclear Weapons

(4) Radiation Test Facilities and Capabilities, 1997, DASIAC, 2560 Huntington Ave., Alexandria, VA 22303 (also on web site: http://www.dswa.mil/dswainfo/es/hp.htm)

(5) J. C. Martin on Pulsed Power, Edited by T. H. Martin, A. H. Guenther, and M. Kristiansen, Plenum Press,
New York and London, 1996, ISBN 0-306-45302-9.

KEYWORD LIST: Advanced Simulator, Above Ground Test (AGT), X-Ray, Debris, Pulsed Power, Radiation, Simulation, Modeling, Test, Electronics, Optics, Nuclear Weapon Effects, Electromagnetic, Electrothermal, Hybrid Electric Guns, High Coulomb Switches, Crowbar Diodes, High Energy Capacitors, Static Electrical Storage Devices.

UNITED STATES SPECIAL OPERATIONS COMMAND

Proposal Submission

The United States Operations Command's (USSOCOM) mission includes developing and acquiring unique special operations forces (SOF) equipment, material, supplies and services. USSOCOM is seeking small businesses with a strong research and development capability and an understanding of the SOF operational characteristics. The 4 topics represent a portion of the problems encountered by SOF in fulfilling its mission.

Inquires of a general nature or questions concerning the administration of the SBIR program should be addressed to:

United States Special Operations Command
Attn: SOAL-KS/Ms. Karen L. Pera
7701 Tampa Point Blvd.
MacDill Air Force Base, Florida 33621
Email: perak@socom.mil

USSOCOM has identified 4 technical topics for the FY02.1 solicitation and proposals will only be accepted for those topics. The USSOCOM Program Executive Officers (PEOs) responsible for the research and development in these specific areas initiated the topics and are responsible for the technical evaluation of the proposals. Proposal evaluation factors are listed below and each proposal must address each factor in order to be considered for an award. Prior to December 1, 2001, scientific and technical questions may be directly asked of the topic author, and after that, through the DTIC SBIR Interactive Technical Information System (SITIS).

The maximum amount of SBIR funding for a USSOCOM Phase I award is $100,000 and the maximum time frame for a Phase I proposal is 6 months. A Phase I proposal for less than 6 months and/or less than $100,000 is encouraged where low risk technologies are being proposed.

USSOCOM will request Phase II proposals on a case by case basis. The proposal must be structured as follows: the first 10-12 months (base effort) should be approximately $375,000; the second 10-12 months (option) of incremental funding should also be approximately $375,000. A Phase II proposal for less than 24 months and/or less than $750,000 is encouraged. The maximum amount of **SBIR funding** allocated for a USSOCOM Phase II award is $750,000 and the maximum time frame for a Phase II award is 24 months. Proposals should be based on realistic cost and time estimates, not on the maximum time (months) and dollars. The cost of the project is based on the overall amount of hours spent to accomplish the work required and the overall term of the project should also be based on the same effort. In preparing the proposal, (including the plan of objectives and milestones), firms should consider that workload and operational tempo will preclude extensive access to government and military personnel beyond established periodic reviews.

Evaluation Criteria – Phase I & II

1) The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.

2) The qualifications of the proposed principal/key investigators supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.

3) The potential for commercial (Government of private sector) application and the benefits expected to accrue from this commercialization.

Selection of proposals for funding is based upon technical merit and the evaluation criteria included in the solicitation. As funding is limited, USSOCOM will select and fund only those proposals considered to be superior in overall technical quality and most critical. USSOCOM may fund more than one proposal in a specific topic area if the technical quality of the proposal is deemed superior, or it may fund no proposals in a topic area.

Electronic Submission Instructions

All proposal information <u>must</u> be received electronically via the DoD SBIR/STTR Submission site. To submit, proceed to http://www.dodsbir.net/submission. Once your firm has been registered, they may prepare (and edit) Company Commercialization Report Data, prepare (and edit) Proposal Cover Sheets(s) (formerly referred to as Appendix A and B), complete the Cost Proposal form, and upload corresponding Technical Proposal(s). The electronic proposal must be

transmitted to the site by 3:00PM EST on January 15, 2002. The proposal submission, exclusive of the Company Commercialization Report and the cost proposal must not exceed 25 pages.

Paper copies will not be considered. A complete electronic submission is required for proposal evaluation. An electronic signature is not required on the proposal. Proposal evaluation will be accomplished via a secure web site. Please call the nearest Electronic Commerce Regional Center for assistance in uploading proposals. Please note that there have been problems in the past with AOL uploads, therefore suggest using an alternate internet service provider (ISP) for files larger than 5MB. It is strongly suggested the proposal be submitted 3-5 days prior to closing date to ensure complete submission. Firms are entirely responsible for complete and timely submission of the proposal.

Refer to the on-line help area of the DoD SBIR/STTR Submission site for questions, troubleshooting, etc. For further assistance, contact the help desk at SBIRHELPDESK@pbcinc.com or 866-216-4095.

USSOCOM offers information on the Internet about its SBIR program at http://www.socom.mil and http://www.acq.osd.mil/sadbu/sbir.

Electronic Technical Proposal Upload

The term "Technical Proposal" refers to the part of the submission as described in Section 3 of the Solicitation. WordPerfect, Text, MS Word, RTF, and PDF are the only acceptable formats for proposal submissions. You are encouraged, but not required, to embed graphics within the document. When including images, care should be taken to ensure images are not of excessive size. A resolution of 200 dpi or below is requested for all embedded images. Please use standard fonts in order to prevent conversion difficulties. An overall file size of 5MB or less is recommended for each electronic proposal submission.

You will receive a confirmation page via the submission site once the proposal has been uploaded. The upload will be available for viewing on the DoD SBIR/STTR Submission site within 24 hours. It is within your best interest to review the upload to ensure the server received the complete file. Questions or problems should be directed to the help desk as mentioned above.

You are responsible for performing a virus check on each proposal to be uploaded electronically. The detection of a virus on any submitted electronic technical proposal may be cause for the rejection of the proposal. *USSOCOM will not accept e-mail submissions.* You should contact your Internet Service Providers to if you have questions concerning the provider's file size transmission allowance.

USSOCOM
FY 2002.1 SBIR TOPIC INDEX

Sensors	
SOCOM 02-001	Multi-Spectral Low-Light Imaging
Information Systems	
SOCOM 02-002	Portable Wireless Monitoring Station
Air Platform	
SOCOM 02-003	Lightweight, Disposable Air Cargo Delivery System (LDACD)
Electronics, Information Systems	
SOCOM 02-004	Tactical Antenna Switching and Positioning System (TASPS)

USSOCOM FY 2002.1 SBIR TOPIC DESCRIPTIONS

SOCOM 02-001 TITLE: Multi-Spectral Low-Light Imaging

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Investigate the technical feasibility of fielding reproducible, meaningful, real-time color Image Intensification (I2) devices. This innovation would remove the existing constraint of monochrome (green) imagery of current night vision devices and provide color imagery in its place. Producing color imagery would allow multiple users from different physical locations to identify targets in the scene by color content.

DESCRIPTION: With the recent advances in night vision device performance, a re-examination all aspects of NVG mission performance (i.e.; ability to navigate, detect and maneuver on the battlefield) could produce a dramatic overall increase in operational capability. Current "monochrome" representation of the scene, traditionally exploited by the NVG user communities, could be significantly enhanced if a reproducible color image were presented to the user. Image Intensifiers (I2) function in a range which covers the photopic (light visible to the human eye under daylight conditions) wave band plus (& especially important for low light performance) the near infrared region, which is undetected by the unaided eye. The issue to be examined, is how to create a viable color night vision capability without investing in technologies that are not currently ready for production.Phase I:

PHASE I: Objectives are to:
(1) Model the proposed system configuration for producing color night vision imagery.
(2) Calculate system performance using current performance modeling techniques associated with standard night vision characterization algorithms.
(3) Compare the theoretical performance of the proposed Color Night Vision System to standard night vision system performance.
(4) Develop design and plan to construct a brass-board concept demonstrator.

PHASE II: The Phase II objectives are to:
(1) Build the brass-board concept demonstrator.
(2) Measure system performance under laboratory conditions. Compare results to standard night vision systems.
(3) Measure system performance under real-world scenarios, acquire video footage from Color and standard systems for side by side comparison.
(4) Determine the best approach for transition from brass-board configuration to a fieldable system configuration.

PHASE III DUAL-USE APPLICATIONS: This capability will provide an immediate, increased capability throughout the Military, Intelligence, Law Enforcement, and Search & Rescue communities. There are a host of user communities that have expressed specific interest in the ability to see color imagery under low light level conditions. Law Enforcement, Medical, Search and Rescue, and Fire Fighting communities have expressed specific interest in this capability. The production devices have wide spread use in non-destructive testing, preventative maintenance, medical, forensic, and commercial security applications.

SOCOM 02-002 TITLE: Portable Wireless Monitoring Station

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: SOF tactical users lack a small package that permits them to monitor RF and wireless communications. Having this capability will save lives during dangerous missions. This SBIR will research, design and build a rugged, inexpensive tactical monitoring system for deployed SOF personnel. The system will attempt to use the latest in commercial off the shelf (COTS) and Government off the shelf (GOTS) equipment. The system should use plug and play technology, and provide for future upgrades as technology and signals change.

DESCRIPTION: Wireless communications are a growing mode of communications in all parts of the world. SOF need to be able to monitor communications for force protection. A package that can be integrated into the Joint Threat Warning System (JTWS) Manpack, Team Transportable, Maritime, and/or Air variants will permit SOF to monitor entire regions covered by INMARSAT.

The system will have the following requirements:
- Small and compact (requirement less than 250 cubic inches, objective of 150 cubic inches).
- Ruggedized package for harsh environments, to include no fans.
- Low power (<50W).

- 9-16VDC input power (9-25VDC objective). The Monitoring Station will contain NO internal power; it will be powered via the customer's chosen power source.
- Coherent LO ability for direction finding (DF) applications.
- At least two tuners covering at least 30 to 3000 MHz (objective of 10MHz to 10GHz).
- At least 30MHz bandwidth.
- At least 80dB dynamic range.
- Target database (objective of 5,000 entries).
- NT operating system with removable hard drive.
- Support for 24 control / voice channels.
- Recognize G3 fax signals, and detect the presence of G3 fax and data modem answer tones.
- Support for multiple fax formats.
- Objective of detecting and analyzing spread spectrum/frequency-hopping signals.

The system should utilize DSP technology that is software configurable. It should have the capability of being software upgraded when signals/ configurations change. It will have as an objective to be Joint Component Architecture Framework (JCAF) compliant. Note: SPAWAR Systems Charleston can assist the bidder with the JCAF software. The system should be remoteable using TCP/IP or other standard format. Successful proposals will use novel technology to achieve substantial enhancements to equipment size, weight, performance, reliability, power consumption, data rate speeds, and/or cost or offer new ways of computing, communicating, sensing or displaying information.

PHASE I: Research and propose system design that will provide plan to meet the above requirements and objectives, stressing the small size, power, and the number of formats that can be detected. Efforts should focus on technological approach for addressing the requirement.

PHASE II: Significant interaction with SOF tactical users will be required to ensure that the system being designed will meet their needs. Develop two (2) system prototypes. Will be required to demonstrate in a realistic tactical environment. Conduct limited testing to prove feasibility over a seven day mission scenario.

PHASE III DUAL-USE TECHNOLOGIES: This system is designed primarily for tactical operations, and has application in at least two USSOCOM programs. It will also have application with the other military services and law enforcement agencies. An enterprising company could spin this product off into the commercial market as a wireless maintenance device.

KEYWORDS: INMARSAT, Tactical, Intelligence, monitoring system, cellular, wireless, fax, signals, G3.

SOCOM 02-003 TITLE: Lightweight, Disposable Air Cargo Delivery System (DACD)

TECHNOLOGY AREAS: Air Platform

DESCRIPTION. Lightweight, Disposable Air Cargo Delivery System (LDACDS) to provide Special Operations Forces (SOF) with long-range airdrop resupply and sustainment during operations across the spectrum of SOF operations. This capability to resupply mobile and stationary units operating behind enemy lines with POL, ammunition, weapons/commo, water/food without having to land and or slow down in the air, therefore greatly reducing air-drop signature and greatly improving survivability.

There are no specific technologies of interest. The Services have been working this area for a long time, and tried many different approaches to precision airdrop of small bundles, to include using parachutes, gliding deccelerators, cushioned munitions and pallets. All of these solutions can work, but none of them are optimal. The author is open to any ideas that meet the requirement to include new technologies and application of existing technologies. The cheaper, simpler, and more effective the solution in terms of range, accuracy, signature, and payload, and employment complexity the better. A range of solutions would even be considered for different payloads and range, however, nominal requirements are to deliver 60 pounds of emergency supplies from a wide variety of aircraft with drop speeds of up to 130 knots to within 30ft of intended location.

PHASE I: Compare available and developing technologies against resultant capabilities to provide the government with alternative approach(es) to test, at the concept level. Employment possibilities include fixed and rotary-wing manned and unmanned aircraft.

PHASE II: Based on the optimal solution(s) identified in Phase I, develop prototype systems and demonstrate in controlled field conditions.

PHASE III DUAL USE APPLICATIONS: Precision re-supply in search/rescue and disaster and humanitarian relief situations.

SOCOM 02–004 TITLE: Tactical Antenna Switching and Positioning System (TASPS)

TECHNOLOGY AREAS: Electronics, Information Systems

OBJECTIVE: Design and build an inexpensive lightweight portable Tactical Antenna Switching and Positioning System to be carried aboard and employed on US Navy ships without accessing permanently installed Navy communication assets. The system should be capable of unattended function, and continuous tracking of UHF satellites.

DESCRIPTION: The TASPS will provide a platform for a small lightweight UHF SATCOM antenna and an interface to maintain contact with geosycronus satellites. Contact must be maintained despite ship movement and periodic blockage of the line of sight (LOS) between the antenna and satellite by the ship's superstructure. The system must be capable of unattended operation.

The limited ability for co-use of Navy UFH SATCOM assets creates a dire need for this capability. The Navy has limited SATCOM capabilities for additional users (i.e. those who are not part of the ship's normal company, but base on the ship on a temporary basis). Temporary personnel are required to install additional UHF SATCOM systems. Advantaged antenna placement is in high demand on these ships and special permissions are needed to access the best placement areas. With this proposed system the user is able to board a USNS ship and install systems with little coordination or impact to vital ship's communications and radar systems.

The currently used system employs two directional antennas. The system maintains each antenna's lock on the satellite by turning the antenna at the direction of either a GPS or compass feed. When the ship's superstructure blocks one antenna the system switches to the other antenna. The current system, however, does not work well. The system does not maintain the antenna's lock on satellites well, and high winds further disrupt the directional antenna's tracking. The user envisioned system would interface two UHF SATCOM radios (AN/PRC-117F or equivalent) using one small, man-portable Omni-directional antenna on each side of the ship. The system would switch between the two antennas when the LOS to the satellites is blocked and employs amplifiers and pre amplifiers to make up for the omni-directional antenna's lack of gain. Current technology might also allow a system with directional antennas that are adjusted in accordance with the satellite signal. As the ship turns and signal strength decreases, the antenna automatically turns to maintain its tracking. The current system and user's envisioned future system descriptions are provided not to dictate to potential vendors an approach to the problem, but to help make clear what the problem is. The user is open to innovative and creative solutions to maintaining UHF SATCOM communications while onboard ship.

Regardless of the solution devised, there are several requirements that the system must meet. It must accommodate transmit RF power, in the UHF frequency range (225-400MHz), of 100 watts per channel. It must provide minimal attenuation of the receive signal, to provide maximum possible receive signal level at the radio system. The system must function in an ocean environment, which includes but is not limited to high winds (in excess of 50 knots) and sea spray. The system must be DAMA compliant. The system must be capable of being transported on commercial aircraft and should be contained in not more than two hardened cases weighing not more than 60 lbs. each.

PHASE I: Develop overall system design that includes specification of antenna switching and positioning technology, system specification, and protocol operation.

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to prove feasibility over extended operating conditions.

PHASE III DUAL-USE APPLICATIONS: This system could be used in a broad range of military and civilian applications where automatic RF switching and antenna tracking are necessary. Uses on board Coast Guard and Drug Enforcement vessels are potential candidates for this technology.

NATIONAL IMAGERY AND MAPPING AGENCY
SUBMISSION OF PROPOSALS

GENERAL INFORMATION

The mission of the National Imagery and Mapping Agency (NIMA) is to provide timely, relevant, and accurate imagery, imagery intelligence, and geospatial information in support of national security objectives. Therefore, NIMA pursues research that will help guarantee the information edge over potential adversaries. Potential participants unfamiliar with NIMA and its SBIR program can find more information about it on NIMA's SBIR home page at http://www.nima.gov/poc/contracts/sbir/sbir.html.

PHASE I PROPOSAL INFORMATION

NIMA has developed topics to which small businesses may respond in the fiscal year 2002 SBIR Phase I iteration. These topics are described on the following pages. NIMA will accept only unclassified proposals on its topics.

The price of each proposal shall not exceed a total of $100,000, with not more than $70,000 allotted to the base proposal and not more than $30,000 to the option. The option proposal shall be included with the base proposal at the time of submission. NIMA does not participate in the Fast Track program.

All DoD SBIR proposal submission requirements are required of proposals to NIMA. In the proposals, Phase I base and Phase I option costs shall be shown separately. A work breakdown structure (WBS) that shows the number of hours, labor category and name of each person that will work on the SBIR to be assigned to each task and subtask, as well as the start and end dates for each task and subtask, shall be included. WBS is defined as an organized method to break down a project into logical subdivisions or subprojects at lower and lower levels of details.

Selection of Phase I proposals will be according to the evaluation procedures and criteria discussed in this solicitation (refer to section 4.2 at the front of this solicitation).

Potential SBIR participants shall mail or hand-carry one original paper copy (clearly marked, with original signatures) and three copies of each proposal to the NIMA SBIR Contracting Officer, Captain Brad K. Burhite:

NIMA
Attn: Captain Brad K. Burhite
4600 Sangamore Rd. Mail Stop D-5
Bethesda, MD 20816-5003

To hand-carry the documents, participants shall contact Captain Brad K. Burhite to arrange a delivery time.
Telephone: (301) 227-1412
Fax: (301) 227-4793
e-mail: burhiteb@nima.mil

The original paper copy and each copy must include the Proposal Cover Sheet, the Cost Proposal, and the Company Commercialization Report. All proposals must be received by the date and time indicated in Section 6.2 of the introduction to this solicitation.

Proposal submission questions shall be addressed to Captain Brad Burhite. All other questions shall be directed to the NIMA SBIR Program Manager, Mr. Derrick Riddle:

NIMA
Attn: Derrick Riddle
4600 Sangamore Rd. Mail Stop D-82
Bethesda, MD 20816-5003

Telephone: (301) 227-7508
Fax: (301) 227-3332
e-mail: riddled@nima.mil.

NIMA FUNDING POLICY:

Due to limited funding, NIMA reserves the right to limit awards under either topic, and only those proposals of superior scientific and technical quality will be funded.

PHASE I CONTRACT INFORMATION:

NIMA typically provides a firm fixed price contract for Phase I award . The type of contract is at the discretion of the contracting officer.

Each NIMA Phase I contract shall have a base period of performance of not more than six months, with an option of not more than three additional months. Exercise of the option will be at the sole discretion of NIMA.

If a vendor occupies space in a NIMA activity or has a support contract to provide services outside of an SBIR Phase I, II or III contract award with NIMA, they must indicate this on the front of the Proposal Cover Sheet. NIMA is concerned with potential conflicts of interest. If a vendor replies yes to either of these questions, and it is determined that their participation in the NIMA SBIR program would create a conflict of interest, then the vendor will not be allowed to participate in NIMA's SBIR program.

Federally Funded Research and Development Contractors (FFRDC) may be used in the evaluation of your proposal.

Phase I options will be awarded only to those vendors selected to submit Phase II proposals. In order to determine which vendors will receive Phase I options and a chance to submit a Phase II proposal, Phase I contracts shall include a requirement to produce an interim report not later than 4 1/2 months after award. This report shall include the following sections:

- A summary of the results of the Phase I research to date
- A summary of the Phase I tasks not yet completed, including the Option, with an estimate of the completion date for each task
- A statement of potential applications and benefits of the research.

The report shall be no more than 750 words long. The report shall be prepared single spaced in 12 pitch or 11 point Times New Roman font, with at least a one inch margin on top, bottom, and sides, on 8 ½" by 11" paper. The pages shall be numbered. The report shall be evaluated on the same criteria used to evaluate Phase I proposals.

Those vendors who are selected to submit Phase II proposals will be notified in writing.

PHASE II GUIDELINES

NIMA typically provides a cost plus fixed fee contract as a Phase II award. The type of contract is at the discretion of the Contracting Officer.

Phase II proposals shall be limited to $500,000 over a two year period, with a $250,000 base proposal (first year) and a $250,000 option period (second year). Phase II base and Phase II option costs shall be shown separately in the proposal. A work breakdown structure that shows the number of hours, labor category and name of each person that will work on the SBIR to be assigned to each task and subtask, as well as the start and end dates for each task and subtask, as well as the start and end times for each task and subtask, shall be included. The option shall be included with the base proposal at the time of submission.

Selection of Phase II proposals will be according to the evaluation procedures and criteria discussed in this solicitation (refer to section 4.3 at the front of the solicitation).

Phase II contracts shall include a requirement to produce an interim report not later than 10 months after contract award. This report shall include the following sections:

- A summary of the results of the Phase II research to date
- A summary of the Phase II tasks not yet completed, including those in the Option year, with an estimate of the completion date for each task
- A statement of potential applications and benefits of the research.

The report shall be no more than 750 words long. The report shall be prepared single spaced in 12 point Times New Roman font, with at least a one inch margin on top, bottom, and sides, on 8 ½" by 11" paper. The pages shall be numbered. The report shall be evaluated in accordance with this solicitation (refer to section 4.3 of this solicitation).

Those SBIR participants that are selected to submit Phase II proposals will receive a detailed package of NIMA submission requirements.

NIMA PROPOSAL CHECKLIST

This is a Checklist of Requirements for your proposal. Please review the checklist carefully to ensure that your proposal meets NIMA SBIR requirements. Failure to meet these requirements will result in your proposal not being considered for review or award. Do not include this checklist with your proposal.

_____ 1. The Proposal Cover Sheet (formerly Appendix A and B) was completed using the SBIR proposal submission system, which can be accessed directly at http://www.dodsbir.net/submission. The Proposal Cover Sheet clearly shows the proposal number assigned by the system to your proposal. Indicate if you are a NIMA support contractor.

_____ 2. The proposal addresses a Phase I effort (up to $70,000 with up to a six-month duration) AND an optional effort (up to $30,000 with up to a three-month duration).

_____ 3. The proposal is limited to only ONE NIMA solicitation topic.

_____ 4. The Project Summary on the Proposal Cover Sheet contains no proprietary information, does not exceed 200 words, and is limited to the space provided.

_____ 5. The Technical Content of the proposal, including the Option, includes the items identified in Section 3.4 of the solicitation.

_____ 6. The Company Commercialization Report is submitted in accordance with Section 3.4.n. This report is required even if the company has not received any SBIR funding (This report does not count towards the 25-page limit).

_____ 7. The proposal, including the Phase I Option, is 25 pages or less in length (excluding the Company Commercialization Report). Proposals in excess of this length will not be considered for review or award.

_____ 8. The proposal contains only pages of 8-1/2" x 11" size. No other attachments such as disks or videotapes are included.

_____ 9. The proposal contains no type smaller than 12 pitch or 11 point font size (except as legend on reduced drawings, but not tables), Times New Roman font and a one inch margin on top, bottom and sides

_____ 10. The Cost Proposal (Reference A) has been completed for the Phase I and Phase I Option and their costs are shown separately. The Cost Proposal is included at the end of the proposal.

_____ 11. The proposal is stapled in the upper-left-hand corner, and no special binding or covers are used.

_____ 12. An original with original signatures (clearly marked) and three copies of the proposal are submitted.

_____ 13. Include a self-addressed, **stamped** envelope and a copy of the Notification Form located in the back of the solicitation book, if notification of proposal receipt is desired. No responses will be provided if these are not included with your proposal.

_____ 14. The proposal must be sent registered or certified mail, postmarked by January 9, 2002, or delivered to the NIMA SBIR Office no later than January 16, 2002, 3:00 p.m. EST (see Section 6.2). Offerors who elect to use commercial courier services do so at their own risk. NIMA can not accept responsibility for proposals delivered late by commercial couriers.

NATIONAL IMAGERY AND MAPPING AGENCY
SBIR 02.1 TOPIC DESCRIPTIONS

NIMA 02-001

TOPIC: Imagery Exploitation Applications of Neuroscience

TECHNOLOGY AREAS: Human Systems Interface, Battle Space Environments

OBJECTIVE: Explore and develop applications of neuroscience to imagery intelligence and geospatial analysis for detection, change analysis, extraction, attribution, guided /inferred utility, exploitation or use within NIMA and eventual deployment as tools in open system environments.

DESCRIPTION: Neuroscience has recently shown great advances in knowledge of how biological systems work. Some of this knowledge pertains to how the brain works, how it classifies and attains cognition, and how complexity in the brain arises that leads to intelligence. Although still in its infancy, it is already suggesting new approaches to developing artificial systems for recognition and cognition that can be applied to a wide variety of Intelligence and Geospatial communities' analysis and exploitation problems. Interest is in Neuroscience-inspired proposals based on recent published research, and not in further work in artificial neural network (ANN) applications.

PHASE I: Identify, evaluate or develop, and assess neuroscience technologies as applied to imagery exploitation across the electromagnetic spectrum. Develop a design concept and demonstrate first principle results.

PHASE II: Create a prototype application to further develop and demonstrate the utility of identified neuroscience technologies against defined imagery intelligence and geospatial science applications. Develop the functional interfaces to implement the technologies into NIMA and military exploitation systems.

PHASE III DUAL USE APPLICATIONS: In addition to the above military applications, medical personnel who exploit imagery from sources such as X-rays and ultrasound for patient diagnosis can use these technologies. Industrial applications include those of image understanding, in areas such as robot control and quality assurance and the commercial geospatial community.

NIMA 02-002

TOPIC: Innovative Technology for Generating Digital Terrain Elevation Data Level 2 (DTED-2) Above 60 degrees N

TECHNOLOGY AREAS: Information Systems, Battlespace, Space Platforms

OBJECTIVE: Develop and demonstrate innovative approaches that provide a technical capability to efficiently generate DTED-2 above 60 degrees N latitude.

DESCRIPTION: There is an existing requirement for global Digital Terrain Elevation Data Level 2 (DTED-2). For purposes of this solicitation, DTED-2 is defined as digital terrain elevation data at 1 arc second post spacing (post spacing increases above 50 degrees N), with an absolute horizontal or circular error within 20 meters at least 90 percent of the time (90% CE) and an absolute vertical or linear error within 16 meters at least 90 percent of the time (90% LE). This accuracy is commensurate with the expected result of the Shuttle Radar Topography Mission (SRTM). The bulk of this requirement will be satisfied by data from the SRTM. This technology topic is to address innovative techniques to generate DTED-2 in areas not covered by the SRTM (above 60 degrees N) as well as void areas within the SRTM coverage. NIMA's DTED 1&2 product specifications are defined in Military Product Specification (MIL-PRF) 89020A, 19 April 1996.

PHASE I: Research should address the development of an innovative concept to extract digital elevation data from currently available image sources, for example, sources such as RADARSAT or IKONOS. The density and accuracy of the elevation data should be compatible with the SRTM-derived DTED. This phase should also include a demonstration of the technology over two small sites selected by NIMA. Minimizing the need for ground control is highly desirable and will be a factor in assessing the feasibility of the concept.

PHASE II: The technique in Phase I should be developed to a prototype capability, including an ability to mosaic elevation data to ensure a seamless data set. A prototype demonstration should be performed over several large test areas selected by NIMA to illustrate that the technique meets the desired accuracy and seamless/homogeneous coverage (shear along join edges should not exceed one meter, 90% LE) and is cost effective. The elevation data should contain gaps over no more than one percent of the land area of each one-degree cell, whether caused by clouds or other artifacts. Developers are encouraged to address optional

enhancements to develop a technique to identify and flatten water bodies, to develop a technique to detect vertical obstructions, and to demonstrate a technique to generate bare earth elevations vs. reflective surface elevations.

PHASE III DUAL USE APPLICATIONS: The DTED capability developed in this SBIR initiative can be applied to numerous civil applications and can be transitioned to commercial software systems.

PHASE II: Based on the optimal solution(s) identified in Phase I, develop prototype systems and demonstrate in controlled field conditions.

PHASE III DUAL USE APPLICATIONS: Precision re-supply in search/rescue and disaster and humanitarian relief situations.

SOCOM 02–004 TITLE: Tactical Antenna Switching and Positioning System (TASPS)

TECHNOLOGY AREAS: Electronics, Information Systems

OBJECTIVE: Design and build an inexpensive lightweight portable Tactical Antenna Switching and Positioning System to be carried aboard and employed on US Navy ships without accessing permanently installed Navy communication assets. The system should be capable of unattended function, and continuous tracking of UHF satellites.

DESCRIPTION: The TASPS will provide a platform for a small lightweight UHF SATCOM antenna and an interface to maintain contact with geosycronus satellites. Contact must be maintained despite ship movement and periodic blockage of the line of sight (LOS) between the antenna and satellite by the ship's superstructure. The system must be capable of unattended operation.

The limited ability for co-use of Navy UFH SATCOM assets creates a dire need for this capability. The Navy has limited SATCOM capabilities for additional users (i.e. those who are not part of the ship's normal company, but base on the ship on a temporary basis). Temporary personnel are required to install additional UHF SATCOM systems. Advantaged antenna placement is in high demand on these ships and special permissions are needed to access the best placement areas. With this proposed system the user is able to board a USNS ship and install systems with little coordination or impact to vital ship's communications and radar systems.

The currently used system employs two directional antennas. The system maintains each antenna's lock on the satellite by turning the antenna at the direction of either a GPS or compass feed. When the ship's superstructure blocks one antenna the system switches to the other antenna. The current system, however, does not work well. The system does not maintain the antenna's lock on satellites well, and high winds further disrupt the directional antenna's tracking. The user envisioned system would interface two UHF SATCOM radios (AN/PRC-117F or equivalent) using one small, man-portable Omni-directional antenna on each side of the ship. The system would switch between the two antennas when the LOS to the satellites is blocked and employs amplifiers and pre amplifiers to make up for the omni-directional antenna's lack of gain. Current technology might also allow a system with directional antennas that are adjusted in accordance with the satellite signal. As the ship turns and signal strength decreases, the antenna automatically turns to maintain its tracking. The current system and user's envisioned future system descriptions are provided not to dictate to potential vendors an approach to the problem, but to help make clear what the problem is. The user is open to innovative and creative solutions to maintaining UHF SATCOM communications while onboard ship.

Regardless of the solution devised, there are several requirements that the system must meet. It must accommodate transmit RF power, in the UHF frequency range (225-400MHz), of 100 watts per channel. It must provide minimal attenuation of the receive signal, to provide maximum possible receive signal level at the radio system. The system must function in an ocean environment, which includes but is not limited to high winds (in excess of 50 knots) and sea spray. The system must be DAMA compliant. The system must be capable of being transported on commercial aircraft and should be contained in not more than two hardened cases weighing not more than 60 lbs. each.

PHASE I: Develop overall system design that includes specification of antenna switching and positioning technology, system specification, and protocol operation.

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to prove feasibility over extended operating conditions.

PHASE III DUAL-USE APPLICATIONS: This system could be used in a broad range of military and civilian applications where automatic RF switching and antenna tracking are necessary. Uses on board Coast Guard and Drug Enforcement vessels are potential candidates for this technology.

9.0 SUBMISSION FORMS AND CERTIFICATIONS

Section 9.0 contains:

Reference A: **Cost Proposal Outline**
A cost proposal following the format in Reference A must be included with each proposal submitted.

Reference B: **Fast Track Application Form**
A DoD program under which projects that attract outside investors receive interim funding and selection for Phase II award provided they are "technically sufficient" and have substantially met Phase I goals.

Reference C: **Proposal Receipt Notification Form**

Reference D: **Directory of Small Business Specialists**

Reference E: **SF 298 Report Documentation Page**

Reference F: **DoD Fast Track Guidance**

Reference G: **DoD's Critical Technologies**

Reference H: **DoD SBIR/STTR Mailing List Form**

U.S. DEPARTMENT OF DEFENSE

SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
COST PROPOSAL

Background:

Offerors should indicate the following terms, as appropriate, in their proposal, following the instructions in Section 3.4(m) of this solicitation. If desired, offerors may complete and submit their cost proposal electronically, through the DoD Electronic Submission Web Site (http://www.dodsbir.net/submission).

Cost Breakdown Items (in this order, as appropriate):

1. Name of offeror
2. Home office address
3. Location where work will be performed
4. Title of proposed effort
5. Company's taxpayer identification number and CAGE code. *(Note: Offerors that do not yet have these items -- e.g., because the company does not yet exist at the time of proposal submission -- should so indicate in the cost proposal. Such offerors, if selected for award, should talk with their DoD contracting officer about obtaining these items, both of which are required before a contract can be awarded.)*
6. Topic number and topic title from DoD Solicitation Brochure
7. Total dollar amount of the proposal
8. Direct material costs
   a. Purchased parts (dollars)
   b. Subcontracted items (dollars)
   c. Other
      (1) Raw material (dollars)
      (2) Your standard commercial items (dollars)
      (3) Interdivisional transfers (at other than cost dollars)
   d. Total direct material (dollars)
9. Material overhead (rate_____%) x total direct material = dollars
10. Direct labor (specify)
    a. Type of labor, estimated hours, rate per hour and dollar cost for each type (e.g., "computer programmer, 40 hours, $26 per hour, $1040 cost") Include the name as well as hours, etc. of all key personnel.
    b. Total estimated direct labor (dollars)
11. Labor overhead
    a. Identify overhead rate, the hour base and dollar cost
    b. Total estimated labor overhead (dollars)
12. Special testing (include field work at government installations)
    a. Provide dollar cost for each item of special testing
    b. Estimated total special testing (dollars)
13. Special equipment
    a. If direct charge, specify each item and cost of each
    b. Estimated total special equipment (dollars)
14. Travel (if direct charge)
    a. Transportation (detailed breakdown and dollars)
    b. Per diem or subsistence (details and dollars)
    c. Estimated total travel (dollars)
15. Subcontracts (e.g., consultants)
    a. Identify each, with purpose, and dollar rates
    b. Total estimated subcontracts costs (dollars)
16. Other direct costs (specify)
    a. Total estimated direct cost and overhead (dollars)
17. General and administrative expense
    a. Percentage rate applied
    b. Total estimated cost of G&A expense (dollars)
18. Royalties (specify)
    a. Estimated cost (dollars)
19. Fee or profit (dollars)
20. Total estimate cost and fee or profit (dollars)
21. The cost breakdown portion of a proposal must be signed by a responsible official, and the person signing must have typed name and title and date of signature must be indicated.
22. On the following items offeror must provide a yes or no answer to each question.
    a. Has any executive agency of the United States Government performed any review of your accounts or records in connection with any other government prime contract or subcontract within the past twelve months? If yes, provide the name and address of the reviewing office, name of the individual and telephone extension.
    b. Will you require the use of any government property in the performance of this proposal? If yes, identify.
    c. Do you require government contract financing to perform this proposed contract? If yes, then specify type as advanced payments or progress payments.
23. Type of contract proposed, either cost-plus-fixed-fee or firm-fixed price.

REFERENCE B

U.S. DEPARTMENT OF DEFENSE

SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
FAST TRACK APPLICATION COVER SHEET

Failure to fill in all appropriate spaces may cause your application to be disqualified

To qualify for the SBIR Fast Track, a company must submit a Fast Track application and meet the other requirements detailed in Section 4.5 of the solicitation. This form, when completed and signed by both the company and its investor, should be included as the cover sheet of the Fast Track application. Instructions on where to submit the application are on the back of this form.

TOPIC #: ____________ CONTRACT #: ____________________

PHASE I EFFECTIVE START DATE: ______________

PHASE I COMPLETION DATE: ______________

SPONSORING DOD COMPONENT: ______________________________

PHASE I TITLE: ____

____

FIRM NAME: ____

MAIL ADDRESS: ____

CITY: ______________________________ STATE: __________ ZIP: __________

TAXPAYER IDENTIFICATION NUMBER: ____________________

NAME OF OUTSIDE INVESTOR: ____

MAIL ADDRESS: ____

CITY: ______________________________ STATE: __________ ZIP: __________

TAXPAYER IDENTIFICATION NUMBER: ____________________

BUSINESS CERTIFICATION:

	YES	NO
> Has your company ever received a Phase II SBIR or STTR award from the federal government (including DoD)? If yes, the minimum matching rate is $1 for every SBIR dollar. If no, the minimum matching rate is 25 cents for every SBIR dollar. (Matching rates differ slightly for BMDO applicants – see the BMDO section of this solicitation)	☐	☐
> Does the outside funding proposed in this application qualify as a "Fast Track investment", and does the investor qualify as an "outside investor", as defined in DoD Fast Track Guidance (Reference F)? If you have any questions about this, call the DoD SBIR Help Desk (866-216-4095). The Help Desk will refer any policy and/or substantive questions to appropriate DoD personnel for an official response.	☐	☐

Caution: knowingly and willfully making any false, fictitious, or fraudulent statements or representations above may be felony under the Federal Criminal False Statement Act (18 U.S.C. Sec 1001), punishable by a fine of up to $10,000, up to five years in prison, or both.

PROPOSED SBIR AND MATCHING FUNDS:

> Proposed DoD SBIR funds for the interim effort: $______________

> Proposed DoD SBIR funds for Phase II: $______________

> Total proposed DoD SBIR funds (interim + Phase II): $______________

> Amount of matching funds (cash) the investor will provide: $______________

By signing below, the parties are stating that the outside investor will provide matching funds, in the amount listed above, contingent on the company's selection for Phase II SBIR award. If the matching funds are not transferred from the investor to the company within 45 days after DoD has notified the company that it has been selected for Phase II award, the company will be ineligible to compete for a Phase II award not only under the Fast track but also under the regular Phase II competition, unless a specific written exception is granted by the Component SBIR program manager.

COMPANY OFFICIAL		OUTSIDE INVESTOR OFFICIAL	
NAME: ____________________		NAME: ____________________	
TITLE: ____________________		TITLE: ____________________	
TELEPHONE: ____________________		TELEPHONE: ____________________	
SIGNATURE	DATE	SIGNATURE	DATE

Nothing on this page is classified or proprietary information/data

INSTRUCTIONS FOR COMPLETING FAST TRACK COVER SHEET

SUBMISSION:

Submit the Fast Track application, including the three items discussed in Section 4.5(b), to the technical monitor for your Phase I project. In addition, submit a copy of the entire application to the Program Manager of the DoD Component funding the SBIR project (addresses below). Finally, send a copy of this application cover sheet, when completed, to the DoD SBIR Program Manager, OSD/SADBU, 1777 N. Kent Street, Suite 9100, Arlington, VA 22209. Do not submit other items in the Fast Track application to the DoD SBIR Program Manager.

Department of the Army
Dr. Kenneth A. Bannister
Army SBIR Program Manager
Army Research Office - Washington
5001 Eisenhower Avenue, Room 8N23
Alexandria, VA 22333-0001

Department of the Navy
ONR 362 SBIR
ATTN: Vincent Schaper
800 N. Quincy Street
Arlington, VA 22217-5660

Department of the Air Force
AFPL/XPTT, Steve Guilfoos
1864 4th Street, Suite 1, Bldg.15
Wright Patterson AFB, OH 45433-7131

Defense Advanced Research Projects Agency
ATTN: SBIR Program Manager Ms. C. Jacobs
3701 N. Fairfax Drive
Arlington, VA 22203-1714

Chemical and Biological Defense Program
Dr. Kenneth A. Bannister
Army Research Office – Washington
5001 Eisenhower Avenue, Room 8N23
Alexandria, VA 22333-0001

Ballistic Missile Defense Organization
ATTN: TOI/SBIR (Jeff Bond)
1725 Jefferson Davis Highway
Suite 809
Arlington, VA 22202

Office of the Director, Defense Research and Engineering
Lab Management & Tech Transition
ATTN: SBIR Program Manager
3040 Defense Pentagon
Washington, DC 20301-3040

Defense Threat Reduction Agency
Defense Threat Reduction Agency
ATTN: Mr. Ron Yoho, Program Manager
DTRA/TDC
8725 John J. Kingman Drive, MSC 6201
Fort Belvoir, VA 22060-6201

US Special Operations Command
ATTN: SOSB/Ms Karen L. Pera
7701 Tampa Point Blvd.
MacDill AFB, FL 33621-5323

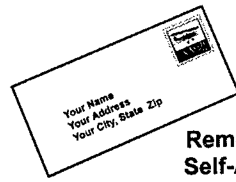
National Imagery and Mapping Agency
Attn: Karen I. Palmer
4600 Sangamore Rd. Mail Stop D-88
Bethesda, MD 20816-5003
Mail-Stop: P-53

ELECTRONIC VERSIONS OF THIS FORM ARE AVAILABLE.

This form is available in HTML format, which allows you to complete the form electronically and print out a hard copy to submit to DoD – see http://www.sbirsttr.com/sbirmisc/refb/form.html. Also, additional hard copies of this form may be obtained from:

DoD SBIR Help Desk
7000 North Broadway
Building 1, Suite #108
Denver, CO 80221
(866) 216-4095

Proposer: If you wish to be notified that your proposal has been received, please submit this form *__with a stamped, self-addressed envelope__*.



Remember to Stamp Your Self-Addressed Envelope!

TO: ______________________________

____

____

Fill in firm's name and mailing address

SUBJECT: SBIR Solicitation No. 02.1

Topic No.
Fill in Topic No.

Proposal Title ______________________________
Fill in the Title of Your Proposal

This is to notify you that your proposal in response to the subject solicitation and topic number has been received by

____
Fill in name of organization to which you will send your proposal.

______________________________ ____________
Signature by receiving organization Date

Associate Directors of Small Business assigned at Defense Contract Management Districts (DCMD): (DCMD EAST -- http://www.dcmde.dla.mil; DCMD WEST -- http://www.dcmdw.dla.mil)

DCMD EAST (DCMDE-DU)
ATTN: Steven T. Shea
495 Summer Street, 8th Floor
Boston, MA 02210-2184
(617) 753-4318
(617) 7533174 (FAX)
bdu1150@dcmde.dla.mil

DCMC Atlanta (DCMDE-GADU)
ATTN: Jim Masone
805 Walker Street, Suite 1
Marietta, GA 30060-2789
(770) 590-6197
(770) 590-6551 (FAX)
jmasone@dcmde.dla.mil

DCMC Lockheed Martin Marietta (DCMDE-RHD)
ATTN: Erma A. Peacock
86 South Cobb Drive, Building B-2
Marietta, GA 30063-0260
(770) 494-2016
(770) 494-7883 (FAX)
epeacock@dcmde.dla.mil

DCMC Baltimore (DCMDE-GTDU)
ATTN: Gregory W. Prouty
217 East Redwood St.
Baltimore, MD 21202
(410) 962-9735
(410) 962-3349 (FAX)
gprouty@demde.dla.mil

DCMC Birmingham (DCMDE-GLDU
ATTN: Jim W. Brown
Burger Phillips Center
1910 3rd Avenue, N., Suite 201
Birmingham, AL 35203-3514
(205) 716-7403
(205) 716-7875 (FAX)
jibrown@dcmde.dla.mil

DCMC Boston (DCMDE-GFDU)
ATTN: Philip R. Varney
495 Summer Street
Boston, MA 02210-2138
(617) 753-3467/4110
(617) 753-4005 (FAX)
pvarney@dcmde.dla.mil

DCMC Indianapolis (DCMDE-GIDU)
ATTN: D. Middleton
8899 E 56th Street
Indianapolis, IN 46249-5701
(317) 510-2015
(317) 510-2348 (FAX)
dmiddleton@dcmde.dla.mil

DCMC Clearwater (DCMDE-GCDU)
ATTN: Sandra Scanlan
Gadsen Building
9549 Koger Blvd., Suite 200
St. Petersburg, FL 33702-2455
(727) 579-3093
(727) 579-3106 (FAX)
sscanlan@dcmde.dla.mil

DCMC Cleveland (DCMDE-GZDU)
ATTN: Catharine H. Szlembarski
555 E 88th Street
Bratenah, OH 44108-1068
(216) 681-1571
(216) 681-1719 (FAX)
cszlembarski@dcmde.dla.mil

DCMC Dayton (DCMDE-GYDU)
ATTN: Thomas E. Watkins
1725 Van Patton Drive, Building 30, Area C
Wright-Patterson AFB, OH 45433-5302
(937) 656-3104
(937) 656-3228 (FAX)
twatkins@dcmde.dla.mil

DCMC Detroit (DCMDE-GJDU)
ATTN: David C. Boyd
Building 231
Warren, MI 48397-5000
(810) 574-4474
(810) 574-6078 (FAX)
dboyd@dcmde.dla.mil

DCMC Hartford (DCMDE-GUDU)
ATTN: Carl Cromer
130 Darlin Street
East Hartford, CT 06108
(860) 291-7705
(860) 291-7779 (FAX)
ccromer@dcmde.dla.mil

DCMC Long Island (DCMDE-GGDU)
ATTN: Eileen Kelly
605 Stewart Ave
Garden City
Long Island, NY 11530-4761
(516) 228-5722
(516) 228-5938 (FAX)
bvc2251@dcrb.dla.mil

DCMC Syracuse (DCMDE-GSDU)
ATTN: Ralph Vinciguerra
615 Erie Blvd, West
Syracuse, NY 13204
(315) 448-7897
(315) 448-7914 (FAX)
bsu6449@dcmde.dla.mil

DCMC New York (DCMC-GNDU)
ATTN: John Castellane
Ft. Wadswoth
207 New York Avenue
Staten Island, NY 10305-5013
(718) 390-1016
(718) 390-1020 (FAX)
bvn3724@dcmde.dla.mil

DCMC Orlando (DCMDE-GODU)
ATTN: Barbara Gaines
3555 Maguire Blvd
Orlando, FL 32803-3726
(407) 228-5149
(407) 228-5221 (FAX)
bgaines@dcmde.dla.mil

DCMC Pittsburgh (DCMDE-GPDU)
ATTN: David Chapman
1612 Federal Building
1000 Liberty Avenue
Pittsburgh, PA 15222-4190
(412) 395-5977
(412) 395-5907 (FAX)
dchapman@dcmde.dla.mil

DCMC Springfield (DCMDE-GXDU)
ATTN: Otis Boggs
Building 1, ARDEC
Picatinny, NJ 07806-5000
(973) 724-8204
(973) 724-2496 (FAX)
bgx0659@dcmde.dla.mil

DCMC Philadelphia (DCMDE-GDDU)
ATTN: Yvette Wright
P.O. Box 11427
Philadelphia, PA 19111-0427
(215) 737-5818
(215) 737-5873 (FAX)
ywright@dcmde.dla.mil

DCMD WEST
ATTN: Renee Deavens
18901 S. Wilmington, Bldg DH2
Carson, CA 90746
(800) 222-2556
(310) 900-6025
(310) 900-6029 (FAX)
rdeavens@whq.dcmdw.dla.mil

DCMC Phoenix (DCMDW-GPDU)
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Form Approved
OMB No. 0704-0188

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4. TITLE AND SUBTITLE			5. FUNDING NUMBERS
6. AUTHOR(S)			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)			8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSORING/MONITORING AGENCY REPORT NUMBER
11. SUPPLEMENTARY NOTES			
12a. DISTRIBUTION/AVAILABILITY STATEMENT (see Section 5.3b of this solicitation)			12b. DISTRIBUTION CODE
13. ABSTRACT (Maximum 200 words)			
14. SUBJECT TERMS			15. NUMBER OF PAGES
			16. PRICE CODE
17. SECURITY CLASSIFICTION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT

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DoD Fast Track Guidance

This paper contains DoD's official guidance on what types of relationships between a small company and outside investors in the company qualify as an investment under the SBIR and STTR Fast Track ("Fast Track investment"). It includes specific examples of company-investor relationships that we have been asked about and our official responses on whether these relationships qualify as a Fast Track investment. If you have questions about whether a particular company-investor relationship qualifies, please contact the DoD SBIR/STTR Help Desk (tel. 866/216-4095, fax 866/888-1079, e-mail SBIRHELPDESK@pbcinc.com). The Help Desk will refer any policy or substantive questions to appropriate DoD personnel for an official response.

I. General Guidance on What Qualifies As A "Fast Track Investment"

- The investor must be an "outside investor," which may include such entities as another company, a venture capital firm, an individual "angel" investor, a non-SBIR/non-STTR government program, or any combination of the above. It does not include the owners of the small business, their family members, and/or "affiliates" of the small business, as defined in Title 13 of the Code of Federal Regulations (C.F.R.), Section 121.103. As discussed in that Section:

    - Concerns are affiliates of each other when one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.
    - [We] consider factors such as ownership, management, previous relationships with or ties to another concern, and contractual relationships, in determining whether affiliation exists.
    - Individuals or firms that have identical or substantially identical business or economic interests, such as family members, persons with common investments, or firms that are economically dependent through contractual or other relationships, may be treated as one party with such interests aggregated.

  Although DoD is guided by this definition of affiliation in the Code of Federal Regulations, we also exercise our own discretion in determining whether a particular entity qualifies as an "outside investor."

- The **investment** must be an arrangement in which the outside party provides cash to the small company in return for such items as: equity; a share of royalties; rights in the technology; a percentage of profit; an advance purchase order for products resulting from the technology; or any combination of the above. The investor's funds must pay for activities that further the development and/or commercialization of the company's SBIR technology (e.g., further R&D, manufacturing, marketing, etc.).

II. Specific examples of What Does and Does Not Qualify As a "Fast Track Investment"

A. Examples of What Qualifies as an "Outside Investor"

(1) Can a small company contribute its own internal funds to qualify for the Fast Track?

No. DoD is seeking outside validation of the commercial potential of the company's technology, and therefore requires that the funds come from an outside investor. Also, cash from an outside investor shows up plainly on the company's books and therefore can be more readily verified than a company's own matching contribution.

(2) Company A spins off company B, which wins a phase I SBIR award. Company A then wants to contribute matching funds to qualify company B for the Fast Track. Can A be considered an outside investor for purposes of the Fast Track?

In making our determination of whether company A is an outside investor, we would be guided by the definition of "affiliates" in 13 C.F.R. Sec. 121.103, discussed above. Our presumption is that in this example A and B would be considered "affiliates," and that A would therefore not be an outside investor for purposes of the Fast Track. However, that presumption could be rebutted by showing, for example, that the spin-off occurred several years ago and that A and B do not exercise control over one another, do not have common ownership or management, have different business interests, etc.

(3) Small company S wins a phase I SBIR award. The president of S is a major shareholder in another company Y, which wants to contribute matching funds to qualify S for the Fast Track. Can Y be considered an outside investor?

Our presumption is that Y would not be considered an outside investor. Our determination would be guided by whether the president's stake in Y is large enough that S and Y would be considered "affiliates" under 13 C.F.R. Sec.121.103. Subsection (c.) of Section 121.103 specifically discusses affiliation based on stock ownership:

c. Affiliation based on stock ownership.
   1. A person is an affiliate of a concern if the person owns or controls, or has the power to control 50 percent or more of its voting stock, or a block of stock which affords control because it is large compared to other outstanding blocks of stock.
   2. If two or more persons each owns, controls or has the power to control less than 50 percent of the voting stock of a concern, with minority holdings that are equal or approximately equal in size, but the aggregate of these minority holdings is large as compared with any other stock holding, each such person is presumed to be an affiliate of the concern. If S and Y are found to be affiliates, we would determine that Y is not an outside investor.

(4) Does the outside investor have to be a single entity (e.g., a single venture capital firm) or can it be more than the entity (e.g., two angel investors and a venture capital firm)?

It can be more than one entity.

(5) Small company A contributes matching funds to small company B in order to qualify B for the Fast Track, and, at the same time, B contributes matching funds to A in order to qualify A for the Fast Track. Do A and B qualify as outside investors under the Fast Track?

No. A and B's relationship is such that their investment in each other would not provide outside validation of the commercial potential of their respective SBIR projects. We would therefore not consider them to be outside investors for purposes of the Fast Track.

(6) Can the brother of an employee of small company S contribute funds to qualify S for the Fast Track?

Probably not. Again, we would be guided by the definition of "affiliates" in 13 C.F.R. Sec. 121.103. The brother presumptively would be an affiliate of company S and not an outside investor.

(7) Venture capital firm V currently is a 22 percent shareholder in small company S. Can V invest additional funds in S to qualify S for the Fast Track?

Our presumption is yes. In making our determination, we would be guided by whether V and S are "affiliates," as defined in 13 C.F.R. Sec. 121.103. Section 121.103 provides (in subsection (b)(5)) that a venture capital firm is not affiliated with a company if the venture capital firm does not control the company -- e.g., by owning more than 50 percent of the stock of a small company (prior to its investment under the Fast Track), as described in 13 C.F.R. 107.865.

(8) Large company L makes a cash investment in small company S, and then serves as a subcontractor to S on an SBIR project. Can L's investment in S count as a matching contribution for purposes of the Fast Track?

Only L's cash investment net of its subcontracting effort can count as matching funds for purposes of the Fast Track. For example, if L invests $750,000 in S and subcontracts with S for $250,000, only L's net contribution ($500,000) can count as matching funds for purposes of the Fast Track.

(9) Company Y makes a cash investment in small company S for purposes of the Fast Track, and also enters into a separate contract with S under which Y provides certain goods/services to S in return for $500,000. Can Y's cash investment in S count as a matching contribution for purposes of the Fast Track?

As in the previous example, only Y's cash investment net of the $500,000 it receives from S can count as matching funds for purposes of the Fast Track. However, if the separate contract between Y and S pre-dates S's submission of its phase I SBIR proposal, Y's entire cash investment can count as matching funds for purposes of the Fast Track.

(10) A group of investors wishes to invest funds in small company S to qualify S for the Fast Track. One of the investors is the mother of S's president, who wants to contribute $50,000 toward the effort. Can the group's investment in S count as a matching contribution to qualify S for the Fast Track?

The mother's investment of $50,000 does not count, because she is not an outside investor (see item (6) above). Contributions of the other investors can count provided that they meet the other conditions for the Fast Track (e.g., each must be an outside investor).

<u>B. Examples of What Qualifies as an "Investment"</u>

(1) Can a loan from an outside party qualify as an "investment" for purposes of the Fast Track?

No. The rationale behind the Fast Track is that an outside party is betting on the company's success in bringing the technology to market -- not just its ability to repay a loan.

(2) How about a loan that is convertible to equity?

A loan that is convertible to equity at the company's discretion would count as an investment under the following circumstances: (1) the loan is provided by a public entity (e.g., a state agency), or (2) the loan is provided by a private entity, and the SBIR company actually converts the loan to equity before the end of phase I.

(3) Can in-kind contributions from an outside investor count as matching funds under the Fast Track?

No. The matching contribution must be in cash. A cash contribution is a stronger signal of the outside investor's interest in the technology, and can be readily verified.

(4) Can a purchase order from an outside investor count as a matching contribution under the Fast Track?

An advance purchase order for new products resulting from the SBIR project can count as a matching contribution under the Fast Track. The purchase order must be for one or more products directly resulting from the SBIR project (including, for example, a duplicate of the prototype that will be delivered to DoD at the end of phase II). The investor must provide its cash payment to the small business during phase II, within the time frame set out in the solicitation (section 4.5). To ensure that the investor's funds are "at risk," the payment cannot be refundable to the investor if the product is not delivered or does not work.

(5) Can the funds raised from an initial public offering (IPO) count as matching funds for purposes of the Fast Track?

Yes, as long as the offering memo indicates that a portion of the funds from the IPO will pay for work (e.g., R&D, marketing, etc.) that is related to the SBIR project.

(6) If large company L pays small company S for work related to S's SBIR project and expects a deliverable (goods or services) from S in return, would that qualify as an "investment"?

With the exception of an advance purchase order (discussed in (4) above), this arrangement would not qualify as an investment, for the same reason a loan does not qualify. Specifically, in this situation the large company is not betting on the small company's success in bringing the technology to market, but merely on its ability to provide the deliverable.

<u>C. Examples Re: Timing/Logistics of the Fast Track Investment</u>

(1) Can entity E's investment in small company S during the first month of S's phase I SBIR project count as a matching contribution to qualify S for the Fast Track?

Yes, provided that E is an outside and that the other Fast Track conditions are met. The investment can occur any time after the start of the phase I project.

(2) Small company A, which has won a phase I award, spins off small company B to commercialize the SBIR technology. A then convinces angel investor I to invest funds in B. Can I's investment in B count as a matching contribution to qualify A for the Fast Track?

For I's investment in B to qualify A for the Fast Track, DoD must determine that A and B are substantially the same entity, as evidenced, for example, by their meeting the definition of "affiliates" in 13 C.F.R. Sec.121.103.
If DoD determines that A and B are substantially the same entity, I's investment in B could qualify A for the Fast Track. Of course, the parties must also meet the other conditions for the Fast Track (e.g., I must be an outside investor).

(3) Small company S is collaborating with a university on an STTR project. Investor I wishes to provide funds to the university in order to qualify S for the STTR Fast Track. Can I's investment in the university count as a matching contribution to qualify S for the Fast Track?

In order to qualify S for the STTR Fast Track, I's investment of funds must be in small company S, not in the university. S can then subcontract some of the funds to the university. The rationale is that a cash investment in the small company is a very strong indication of commercial potential, whereas an investment in the university is less so.

(4) Must the activities funded by the investor be included in the statement of work for the small company's phase II contract?

No. The investor's funds must pay for activities that further the development and/or commercialization of the company's SBIR technology (e.g., further R&D, manufacturing, marketing, etc.), but these activities need not be included in the phase II contract's statement of work. In practice, funds from private sector Fast Track investors generally are not included in the phase II contract's statement of work, whereas funds from government Fast Track investors (such as DoD acquisition programs) sometimes are.

DoD's Key Technology Areas

The following is an outline of the Defense Technology Area Plan.

1.	**Air Platforms** -- Fixed-Wing Vehicles; Rotary-Wing Vehicles; Integrated High Performance Turbine Engine Technology (IHPTET); Aircraft Power; High-Speed Propulsion and Fuels.
2.	**Chemical / Biological Defense** -- CB Detection; CB Protection; CB Decontamination; CB Modeling and Simulation; Medical Chemical Defense; Medical Biological Defense.
3.	**Information Systems Technology** – Decision making; Modeling & Simulation Technology; Information Management Assurance & Distribution; Seamless Communication; Computing and Software Technology.
4.	**Ground and Sea Vehicles** -- Ground Vehicles; Surface Ship Combatants; Submarines.
5.	**Materials / Processes** -- Materials and Processes for Survivability, Life Extension, and Affordability; Manufacturing Technology; Civil Engineering; Environmental Quality.
6.	**Biomedical** -- Infectious Diseases of Military Importance; Combat Casualty Care; Military Operational Medicine; Medical Radiological Defense.
7.	**Sensors, Electronics and Battlespace Environment** -- Radar Sensors; Electro-Optical Sensors; Acoustic Sensors; Automatic Target Recognition; Integrated Platform Electronics; Radio-Frequency Components; Electro-Optical Technology; Microelectronics; Electronic Materials; Electronics Integration Technology; Terrestrial Environments; Ocean Battlespace Environments; Lower Atmosphere Environments; Space/Upper Atmosphere Environments.
8.	**Space Platforms** -- Launch Vehicles; Space Vehicles; Propulsion [Integrated High-Payoff Rocket Propulsion Technology (IHPRPT)].
9.	**Human Systems** - - Information Display and Performance Enhancement; Design Integration and Supportability; Warrior Protection and Sustainment; Personnel Performance and Training.
10.	**Weapons** - - The Weapons area has three broad categories. 1) Conventional Weapons: Countermine/Mines; Guidance and Control; Guns; Missiles; Ordnance; Undersea Weapons; and Weapon Lethality / Vulnerability. 2) Directed-Energy Weapons: Lasers; and High-Power Microwave. 3) Electronic Warfare: Threat Warning; Self-Protection; and Mission Support.
11.	**Nuclear Technology - -** Warfighter Support; Systems Effects and Survivability; Test and Simulation Technology; Scientific and Operational Computing.

Note: The above information is a summary of the information contained in documents "Defense Technology Plan" (DTIC # A285415) and "Defense Science and Technology Strategy" (DTIC # A285414).

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